POWER

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GRATITUDE

By BERTON BRALEY

They sent me out in the wilderness to build 'em
a power plant
Where there wasn't a rail in thirty miles and the
trails were rough and scant;
They sent me out with a trapper's map and a
husky, healthy gang
That lived and worked from day to day and let
all else go hang;
There wasn't a sign of a wagon road and the
trail was a rocky track,
And we had to take machines apart in pieces a
mule could pack,
So, slow and careful we hiked along—and gee,
what a weary tramp!
Till we reached the place I had planned the dam
and there we made our camp.

The sad coyotes howled
Like some uncanny choir,
And bear and wildcat prowled
Beyond our dying fire,
But we—in slumber deep
We lay the whole night through,
For men must get their sleep
When they have work to do.

The ice came down with the winter, the floods
came down with the spring,
And we fought with that raging river as you fight
with a living thing,
And we heckled the fat directors back there in
the busy town
For they kept trying to stir us up while keeping
expenses down;
Whatever supplies we needed, of lumber,
cement or steel,
I had to beg and pray for in many a wild
appeal,
And while we were bucking nature in tempest
and cold and heat
The fat directors wired me, "Why isn't the job
complete?"

They'd fume and fuss and fret
And scold and interfere,
While we—we simply sweat,
And tried to keep our cheer.
In spite of doubt, delay
And fat directors, too,
We went right on our way
For we had work to do!

They sent me out in the wilderness to build 'em a
power plant
And it's running now as it ought to be, though
some folks said "It can't."
And now that everything's smooth and fine
they've fastened a can to me
And they've put in a brand-new graduate with a
nice fresh school degree.
But say, it was fun while the job was on—a re-
gular man's-size game!—
For we built the dam and power plant in spite
of the bumps that came.
So the boy is welcome to have the job and sit
in the office chair—
There's a power plant in the wilderness—and I
—I put it there!

So if a job you've got
Away "t'ell an' gone,"
Some far and lonesome spot—
I wish you'd take me on;
I'll ship to Borneo
Or China, or Peru,
I don't care where I go
If I've got work to do

Gas Engine and Steam Turbine Power Plants

By W. C. Turner

SYNOPSIS—Hydraulic pumps are used to supply water to nozzles for washing down phosphate pebble rock. A representative power plant consisting of three gas producers and three gas engines, directly connected to electric generators. There are also two water-tube boilers and a 1000-kw. steam turbine.

Due to the development of the phosphate mining industry in Florida, the combined power-plant equipment makes quite a showing of uptodate machinery. About seventeen companies at present are engaged in mining in the pebble rock district by hydraulic means. The strata of phosphate, from 3 to 10 ft. thick, lies under from 3 to 25 ft. of surface ground, or overburden, as it is termed. The latter consists mainly of sand, which is also removed by hydraulic methods. Fig. 1 shows a mine with the overburden removed, also the pit pump and hydraulic guns.

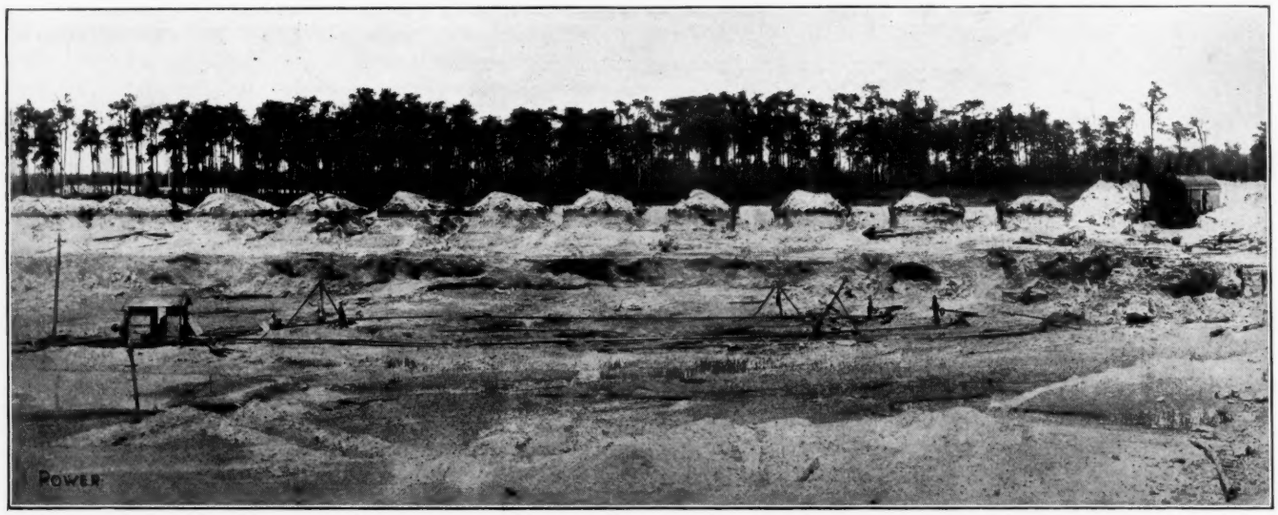

Fig. 1. Phosphate Mine with Overburden Removed, Showing Pit Pump and Hydraulic Guns

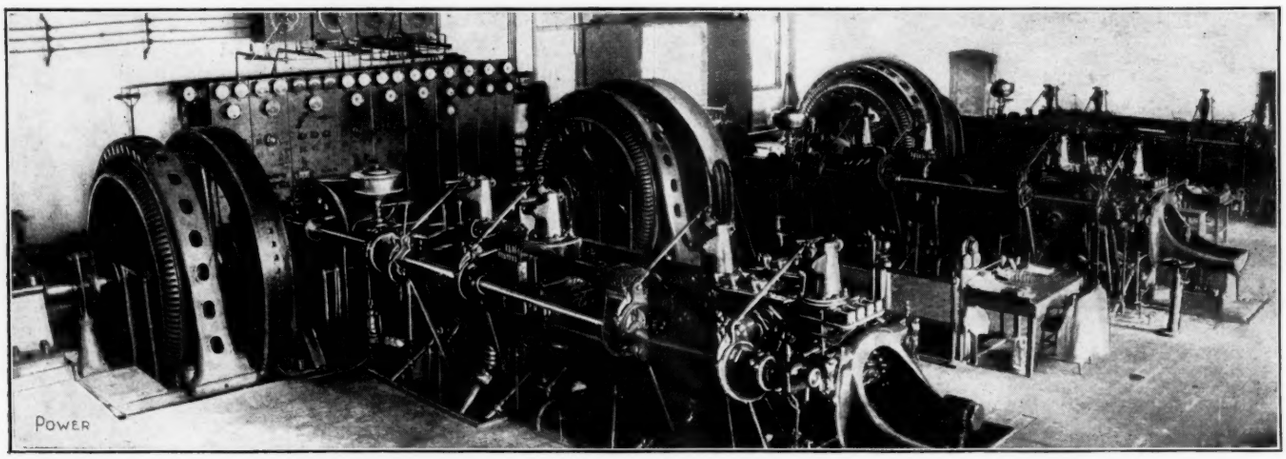

Fig. 2. Gas-Engine Installation at a Phosphate Mine

Hydraulic guns, pivoted in a spherical socket are used to "cut" the bank. They have 2½- to 3-in. smooth-bore nozzles and are supplied with water at a pressure of 125 lb. These nozzles may be swung in any plane through a great range, and permit of starting at the surface and working down, washing the overburden into sumps from which it is removed by direct-connected, motor-driven volute pumps. The phosphate rock is similarly mined, and is pumped to a preliminary washing apparatus.

Until a few years ago the rock was mined by steam-driven units, supplied by conveniently located boilers, the steam lines, however, often being run for a distance of 800 or 900 ft., sometimes over damp ground, and necessarily, on account of periodical changes having to be made in location, were not covered or maintained in the best mechanical condition. The boiler-furnace fuel was wood, of which there was an abundance, but which was finally secured only at great expense, due to the increased distance of hauling and railroad maintenance expense.

Pumps

Pumping stations furnishing water for the guns were located as near the mines as possible, where an abundance of water could be secured. They represented the most

economical means of handling the water and have always been kept up to a high degree of efficiency. Some of these stations contain duplicate triple-expansion pumping units having 15, 24 and 40 by 24-in. cylinders, and surface condensers, the cooling surfaces of which are included in the pump suction lines. A vacuum of 26 in. is maintained. Boilers in each station, of the return-tubular type, supply steam at 125-lb. pressure. These have recently been equipped with oil burners.

Changing from isolated steam-driven to centralized electrical equipment was accomplished at one plant with but slight interruption to the mining operations. A producer-gas power plant was installed in 1909 and was the first step toward centralizing the system.

Gas Equipment

The plant consists of three double-acting, two-cylinder, four-cycle, 18x24-in. gas engines, Fig. 2, running at 200 r.p.m. The engines are supplied with gas by three updraft gas producers, burning bituminous coal. The air blast during operation is furnished by motor-driven fans. Saturated water vapor is generated by waste heat, a

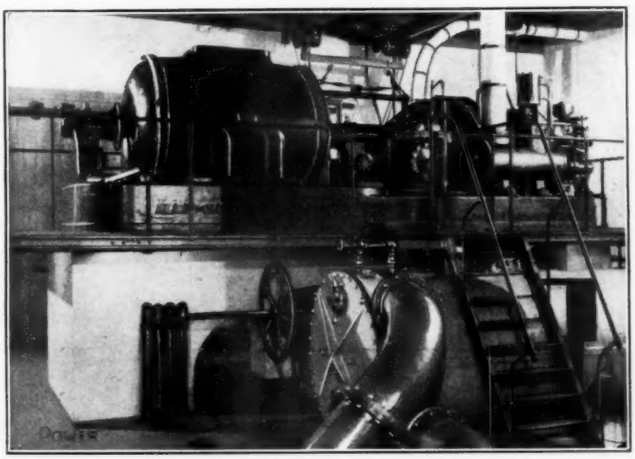

Fig. 3. Steam Turbine and Auxiliaries

vaporizer superimposed on the producers absorbing heat from the gas as it goes to the scrubbers. By means of a regulating device which operates from the blast pressure, and thermometers inserted in the blast pipes convenient for observation, a comparatively close relation of the volume of steam to the air supplied may be maintained at the producer. The gas is cleaned by wet scrubbers and further by centrifugal tar extractors. A 5000-cu.ft. gas holder keeps a constant pressure of $\frac{13}{16}$ in. of water on the engine-supply-gas mains.

All electric generators, directly connected to the engines, are of 200 kw. capacity and deliver 60-cycle current at 2300 volts, which is stepped up to 6600 volts in transformers, located in an adjoining room. At the mines it is stepped down to 550 volts for use in the pump pits, at portable transformer stations, which include switch panels equipped with automatic circuit-breakers, for controlling the various pit motors. The mines are at distances of two and five miles respectively from the power plant.

The power house is near a small lake from which water for all generating purposes is pumped by direct-driven centrifugal pumps; the pump house is near the lake. Recent observations of the gas-plant operation covering a period of 72 hours represent results obtained under the best operating conditions:

Total kilowatt hours at circuit panels	28,990
Total kilowatt hours in generator leads	35,097
(Power metered in the generator leads includes that consumed by station auxiliaries, tar extractors, etc.)	
Per cent. power delivered to circuits of that indicated in generator leads	82.6
Average load factor on generating units, per cent	81.2
Coal consumed, lb.	64,014
Pounds of coal consumed per kw.-hr. delivered from generator	1.824
Average thermal value of gas, B.t.u.	125
Thermal value of coal, B.t.u.	14,500

Circulating-water observations taken at one engine while the engine maintained a load of 225 kw. indicated a circulation per engine, including pistons, of 692.3 lb. of water, which was raised from a temperature of 60 deg. to 88.6 deg. F., hence a heat transfer of 19,799.78 B.t.u. per min., or 59,399 B.t.u. per min. for the three engines, the recovery of part of which was given consideration in the layout of the turbine station.

Steam Plant

Recently, due to increased mining operations, more generating equipment was required and a 100-kw. steam turbine, Fig. 3, was installed. There were also two water-tube boilers of 435 hp., each equipped with superheaters designed to superheat steam of 175-lb. pressure, 125 deg. F. The boilers, Fig. 4, are equipped with oil burners, but the furnaces may be readily converted into coal burners.

Exhaust steam is delivered from the turbine to a surface condenser having a steam-driven dry-vacuum pump, and an electrically driven centrifugal hotwell pump which returns the condensate to an elevated tank, thus maintaining a suitable pressure for a gravity circulation of the return water through heaters in the gas-engine exhausts. A vacuum of 28 in. is maintained with circulating water of 85 deg.

This plant has been in successful operation for some

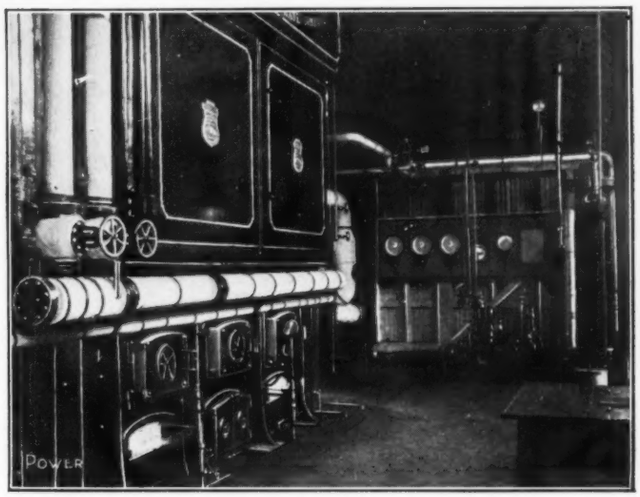

Fig. 4. Boiler Room

months, at about 70 per cent. of its rated capacity. The gas plant is held in readiness for increased mining development.

A complete set of recording instruments is included in the equipment. A turbine inlet pressure gage, in full view of the fireman, indicates the plant-load conditions, and facilitates instant control of the gas burners in response to demands for steam. Permanent sampling apparatus for flue gas has been installed, the CO_2 apparatus

being arranged so that flue-gas analyses may readily be made, or an Orsat may be inserted for a complete analysis.

Provision has been made by tapping into the hotwell return from the condenser for closely checking, by weight or volume, the water rate of the turbine, during regular runs and without inconvenience. A 500-gal. underwriter fire pump connected directly to the boilers is installed, and piped to fire hydrants and taps in the yard and the building interior.

A storage battery of 56 cells, five positive plates per cell, furnishes power for lights and excitation upon starting up. The potential coils of the controlling device are energized from the exciter busbars, and hold open the switch of an auxiliary lighting circuit connected directly on the battery. In the event of an interruption to the main units at night, sufficient light is automatically switched on to enable the operators to handle the apparatus with dispatch and without danger.

Circulating water from the small lake is returned to the extreme end opposite the pump intake, and in flowing from the condenser discharge to the lake on its return passes through several hundred feet of semi-tropical vegetation which absorbs considerable of the initial heat of the water as it leaves the condenser, the drop in temperature before entering the lake is 4 deg.

All circulating pumps and exciter units are electrically driven by synchronous motors, as is also a single-stage, direct-connected air compressor; the latter operates a deep-well air lift. This type of motors was selected on account of its desirable tendency to correct the lagging power factor resulting from the induction motor loads on the feeders. The motor fields are excited from the station-exciter buses. Ammeters indicate the field and armature current.

In view of utilizing the exhaust from the gas engines for heating the feed water, none of the auxiliaries except those of the boilers and the dry-vacuum pump are steam driven. Simplicity is thus secured and there is eliminated the greater possibility of fouling the feed water with oil from their exhausts. An open feed-water heater is used, containing an oil separator which will take care of the exhaust of any steam-driven units which may be installed in the future.

Both plants are so arranged as to be operated by a single crew. On several occasions the gas-engine units have been in parallel with the turbine, and the electrical regulation promises to be all that can be desired.

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Slippage of Reciprocating Pumps

By Mervin K. Baer

SYNOPSIS—It is folly to assume a general figure of 5 per cent. as the slippage of reciprocating pumps. As shown by the test results in this article the slip may be anything from 5 to 85 per cent., depending on the condition of the pump, the discharge pressure and piston speed.

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There is little reliable data obtainable on the slippage of reciprocating pumps; either the indifference on the part of the operating engineer has been the cause of the scarcity of experiments along this line, or else has resulted from this lack of authentic information. In either event, the subject has been passed by with a few statements and figures which are misleading to say the least.

A brief outline of the nature of slip is necessary for the purpose at hand. It may be divided into three losses:

1. Loss due to leakage past the valves, both suction and discharge.
2. Loss due to leakage past the piston or plunger.
3. Loss due to entrained air and to air pockets.

The first is the most important, and is due to the necessarily late seating of the valves, to the wearing of the valves and their springs, and to their improper seating. The second loss is due to the wearing of the piston or plunger, and is liable to be much greater with inside-packed plungers than with those of the outside-packed type. The loss due to entrained air is caused by an exceptionally low suction pressure; that due to air pockets may be charged up to faulty construction. Neither of the last two losses are ever found in a well designed pump.

It is easily seen that the effect of slip is twofold. It reduces the amount of water which can be pumped, and increases the power for a given quantity of water. It is a common occurrence to see the statement that the slip of a certain size pump is, say, 5 per cent. On the strength of such an assertion engineers have used this value promiscuously without considering that there are a great many conditions which tend to change it.

Two factors which enter prominently into the question of slip are piston speed and discharge pressure. Fig. 1 shows how these factors affect the slip of any pump. The region of minimum slip is at the normal rated speed of the pump. The higher the pressure at this point, the higher will be the slip. No matter how high the pressure may be, the slip of the pump is less at this rated speed than at any other speed, the pressure being the same. Going along the curve in either direction, it may be noticed that the slip increases. With a decrease in piston speed, there is a rapid increase in the slip; with an increase in speed, there is likewise an increase in slip, although in this direction it is more gradual. From the standpoint of slippage, it would appear that it is much better to run a pump at a speed higher than normal rather than lower. The fact that the slip increases with the pressure will undoubtedly have been surmised.

Figures were omitted from the curves as no set of values could be given which would cover the entire field of pumps. Each pump will have its own set of curves, depending upon its construction and condition. However, no matter what these may be, the curves will follow the general shape of those shown in Fig. 1. Although no concrete values can be given which will cover the general case, the following instances will give a good idea of the range of values one might expect to find in various pumps:

A 16 and 9 by 12-in. duplex fire pump, whose valves

were in good working order, and whose piston clearances were approximately 0.02 in. for each plunger, was thoroughly tested for slippage. The results are shown in Fig. 2. At 150-lb. pressure the slip was 16 per cent. when the piston speed was about 140 ft. per min., while at 25 ft. per min. the slip jumped up to about 83 per cent. At 10-lb. pressure and 25 ft. per min. piston speed the slip was 31 per cent.; at 140 ft. per min. it was only 5 per cent. These curves give some idea of the immense variations there are in pump slippage.

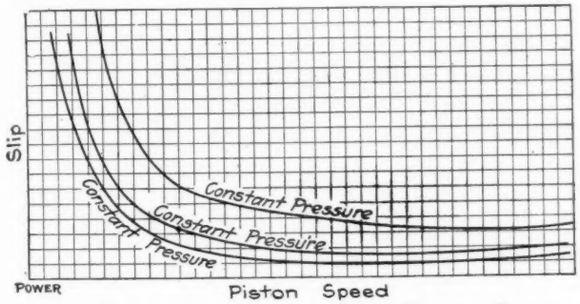

FIG. 1. VARIATION OF SLIP WITH PISTON SPEED AND DISCHARGE PRESSURE

Tests on the pumps of the Chicago water-works showed the following values of slip, under normal operating conditions:

	Slip, per cent.
68th Street station	11.7
Lake View Station	11.8
West Side Station	20.7
22nd Street Station	28.5

A test of pump No. 7 of the Milwaukee water-works, made in June, 1911, showed a slip of 43 per cent.; after repairs were made to the valves, this value was reduced to 9 per cent. These pumps were all large and to see if such large values of slippage existed in smaller pumps, a 24-hr. test was made on a 7½ and 4½ by 6-in. duplex

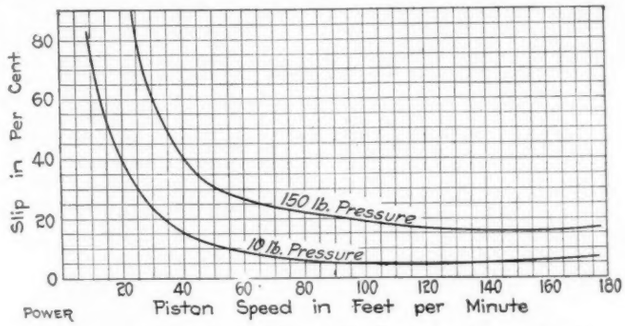

FIG. 2. RESULTS OF TEST ON DUPLEX FIRE PUMP

boiler-feed pump running under normal operating conditions at about 75 lb. pressure and 6 r.p.m. The slip was 58 per cent.

If a pump is not kept in good order the slip may increase rapidly, even if the running conditions are kept constant. The following data are available concerning slippage tests on a 40-million-gal pump:

	Slip, per cent.
June 10	1.7
June 26	5.2
Aug. 8	7.8
Aug. 15	12.4
Sept. 15	20.0
Sept. 18	22.9
Oct. 14	28.5

A careful perusal of the cases just cited, or of a thorough test made on any pump, will show the fallacy of the assumptions that up to the present time have been considered good practice. Engineers are beginning to understand that they cannot assume the slip of their pump to be, say, 5 per cent. They are beginning to realize that there is a wide range of values of slip, and that for the economical operation of their plant they must determine how they can reduce this value to a minimum.

New Riley Underfeed Stoker

The main features of the Riley underfeed stoker are that the coal is forced into slightly inclined retorts by a plunger with which each retort is fitted, the fuel feeding by gravity to the plungers from the hopper about them. The number of retorts and plungers depends upon the width of the stoker.

Moving fuel-bearing grates, placed at an angle of 20 deg., form the upper side of the fuel retorts. They are really narrow grates with side tuyeres for the passage of air from the air space below the grates to the green fuel, below the line of combustion. This feature is shown in Figs. 1 and 2. The grates are baffled, and, although air

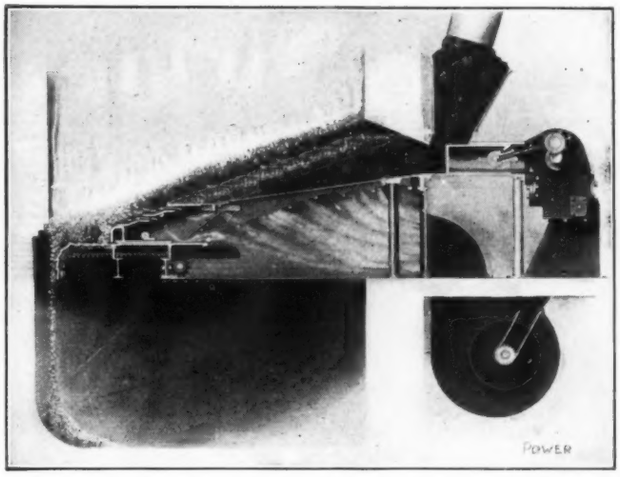

FIG. 1. SECTIONAL VIEW THROUGH STOKER

passes freely through them, ashes or fuel do not sift into the air chamber below. Beyond the underfeed retorts are sets of overfeed grates extending the width of the retorts, Fig. 2.

The overfeed grates reciprocate in unison with the underfeed fuel-bearing grates and also with the plunger, receiving motion from extensions of the plunger wristpins. Each fuel-carrying grate is supported at its upper end by a rod parallel with the coal ram. In the ends of these rods are bolts passing through holes in the plunger pins. By this arrangement, although the plungers make full travel, the movement transmitted to the reciprocating grate is less, due to the lost motion made possible by the distance between the heads of the bolts and the ends of the rods. This lost motion is adjusted by distance blocks to suit the character of the fuel. That is, the plungers make a partial stroke each way before the movement is transmitted to the fuel-bearing grates. This feature is shown in Fig. 3.

At the lower end of the overfeed grates are pusher noses which force the refuse slowly but continuously toward the

rear bridge-wall of the furnace as they move back and forth over a part of the ash-supporting plates. The lower end of the carrying side bars, slide back and forth on a plate at the rear of the stoker just in front of the apron, Fig. 1.

An idea of the ash apron construction can be obtained from Fig. 1. The overlapping plates are supported by racks engaging pinions on a shaft extending to the outside of the furnace setting. The plates of the apron hang down over the end of the racks which can be moved backward or forward by hand and the ash-discharge opening adjusted to suit the amount of refuse from the fuel discharged over the end of the apron into the ashpit. This opening is left just large enough to pass the refuse and

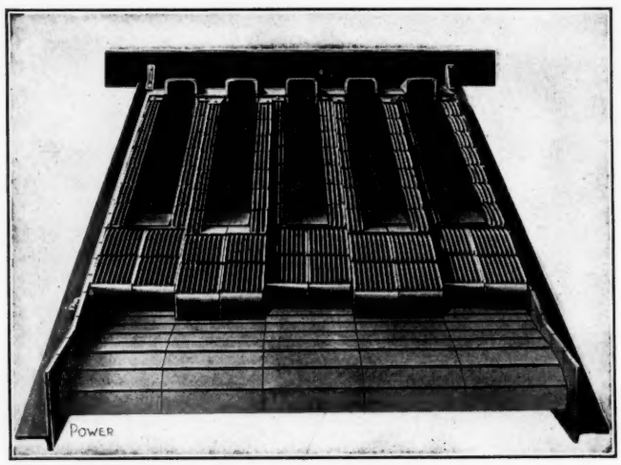

FIG. 2. SHOWING RELATIVE POSITION OF MOVING PARTS

yet maintain an effective air seal between the ashpit and the furnace.

Two I-beams carrying the supporting plates and self-dumping adjustment constitute one assembly unit; three heavy angles, carrying the cylinders and crankshaft, constitute another assembly unit. Each of these units is separately installed and the moving retort parts are dropped into place. The retort bottoms are fixed at their upper ends and their furnace ends slide on the reciprocating overfeed grate extensions.

Precaution against possible damage by obstacles blocking the movement of the plungers is had by using a hardened-steel ring with a pin passing through it and the connecting-rod. The ring bears against the end of the forked sleeve mounted on the wristpin, so that the thrust on the

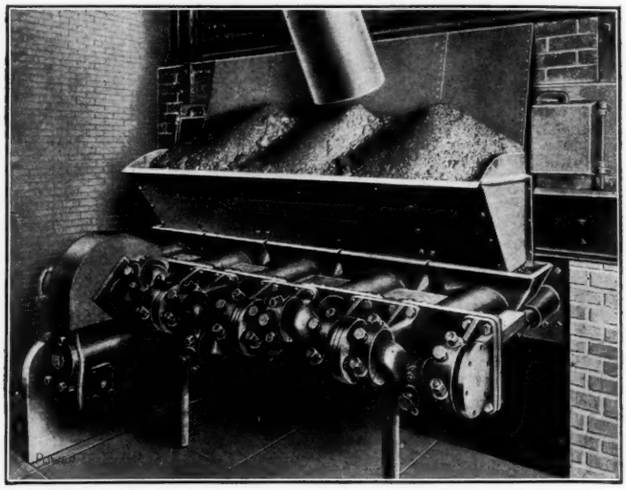

FIG. 4. FRONT VIEW OF THE RILEY STOKER

plunger tends to shear the pin. If the pin shears because of an obstruction in front of the plunger, the connecting-rod slides idly through the sleeve between the ends of the wristpin without carrying the plunger with it. The pin is easily renewed while the stoker is in operation. This safety device is equally effective for all positions of the crankpin.

Connection between the blower and the stoker is by a chain and sprocket wheel, one of which is shown in Fig. 1. The other sprocket delivers power to the gear mechanism which drives the plungers. The stoker and fan work in unison. As the sprocket wheels are placed on the shaft and not removable by the attendant, the ratio of air to the coal fed to the grates is fixed. This adjustment is determined by the flue-gas analysis and so long as the same grade of coal is used the sprocket wheel should not be changed.

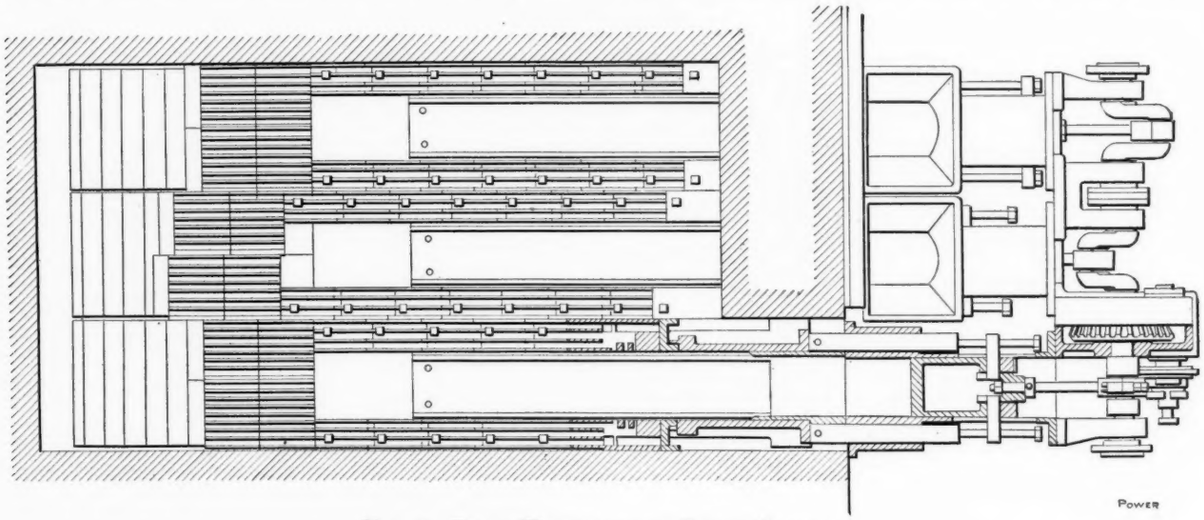

FIG. 3. PLAN VIEW OF THE RILEY STOKER

Referring to Fig. 1, the course of the fuel is easily followed. Dropping from the stoker hopper it is forced into the retorts by the plungers operated by the crankshaft on

the front of the furnace setting, Fig. 4. When the retorts become filled the fuel is carried by the fuel-bearing grates which form the side of the retorts. As these grates are operated in unison with the retort plungers and as each plunger is driven by a crank set at a different angle from the one beside it, the fuel-bearing grates between any two retorts are given a shearing motion in relation with each other, while moving in opposite directions. This motion prevents clinkers forming above the air openings.

The reciprocating motion of the fuel-bearing grates gradually forces the coking and burning fuel toward the rear end of the furnace. Air is supplied to the fuel through the side tuyere openings as indicated by the arrows, Fig. 1. The reciprocating motion of the fuel-bearing grates, the overfeed grates and the pusher noses, all working in unison, forces the refuse toward the bridge-wall over onto the ash-supporting plates and into the ash-pit. Reverberating effect of the hot gases against the grates is impossible because clinkers must break along the line of movement of the grates, and thus give the hot gases free exit to the boiler tubes.

The driving mechanism of the stoker is visible from the outside and accessible. The air space beneath the stoker is reached through a door or through the opening in the front air plate or the side door. Removing the front air plates gives free access to the under part of the stoker for repairs, etc. The stoker requires a small amount of head room, which permits of ample combustion-chamber space. Fig. 1 shows the short air duct between the fan blower and the air space below the stoker. This feature eliminates losses due to the friction of air through long air ducts and the necessary power to maintain the excess air pressure to overcome this loss. Hence, less work is required of the blower fan in maintaining the proper air pressure in the air chamber below the grates.

As the overfeed grates extend entirely across the stoker beyond the underfeed retorts, all of the partially burned fuel comes in intimate contact with air. The air is of less pressure than the underfeed air, and, therefore, is not destructive to the lighter fuel bed on the overfeed grates.

At low ratings this air pressure may be little or nothing, being regulated by the fireman by operating the damper shown in Fig. 1, between the air space and the overfeed reciprocating grate. Therefore, the air is always under the control of the operator, who can burn the combustible in the coal just as completely as he wants to, whether at high or low ratings.

This stoker is manufactured by the Sanford Riley Stoker Co., Worcester, Mass.

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The Bi-centennial of the Steam Engine

By Erick H. Low

SYNOPSIS—In 1712, twenty-four years before James Watt was born, and over sixty years before he and Boulton began to build engines at Soho, the first reciprocating piston engine was put to work. The bicentenary of this epoch-making event has passed without adequate notice.

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Ask a hundred people who invented the steam engine and ninety of them will tell you James Watt, yet he was only one of several inventors who brought the steam engine to a condition of practical and useful application.

The first piston steam engine was erected 200 years ago last year; but the idea of using heat and steam as sources of power is older than the Christian Era.

The first recorded use of heat as a source of power was 200 years B. C., at which time Hero was interested in the subject and we are indebted to his records, as well as to his inventions. His first record tells of a temple door which was opened and closed by heating air. This was probably used to work upon the superstitions of the people for the doors were open as long as a good fire burned on the altar. Fig. 1 shows a working drawing of this engine. The fire on the altar heats the air inside, which expands, exerting a pressure on the water in tank *A*, forcing it through the siphon *B*, into the open bucket *C*, which is hung by a rope which passes over a pulley, and thence to two pillars about which it is wound. *D* is a counterweight which acts on the pillars in the opposite direction from *C*. The pillars are fastened to the edges of the door and as they rotate the doors open or close. As the water fills the bucket, it overbalances the weight *D* and opens the door. When the fire goes out, the air cools and the water runs back through the siphon and the weight pulls the door to.

The next engine, a mere toy, was invented by Hero

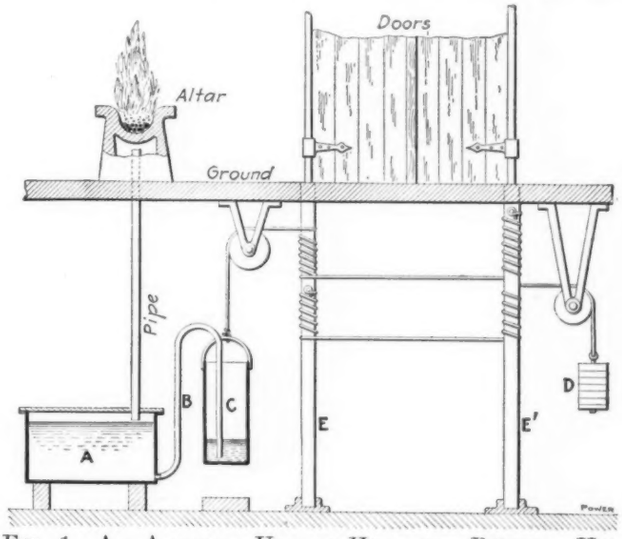


Fig. 1. An Ancient Use of Heat for Power. How the Temple Doors Were Opened by the Altar Fire

himself, and is shown in Fig. 2. It consisted of a boiler *A* and hollow sphere *B* hung in trunnions connected to the pipes *CC'* from the boiler. The sphere had two outlets, *EE*, turned tangent to the sphere and at right angles to the first axis. The steam from the boiler filled the sphere and escaped through the outlets *EE* where the reaction caused the sphere to rotate.

After this there were a number of toys, such as a wheel with a number of buckets, which was blown around by a jet of steam, and different forms of siphon engines. Without doubt, steam was the mysterious agent which performed many of the mediæval miracles; yet the first recorded use of any importance was in 1543. Blasco de Garay, a Spanish naval officer, is said to have built a boat which was run by paddles driven by steam. The king was much pleased with it and promoted him to some high office; but nothing further was heard of his invention and its secret probably died with him.

The Marquis of Worcester writes about an engine, but the records are incomplete and given more to what the engine could do than to how it worked. One of these engines was set up on the Thames about 1653. It raised water more than forty feet.

We now come to the age of rapid development of the steam engine and the first invention is that of Thomas Savery. Toward the end of the 17th century, the mines of England had reached such a depth that water came in too fast to be handled by the old method, and a cry was raised for some new way to keep them dry. In one mine, they employed 600 horses at immense cost. Savery

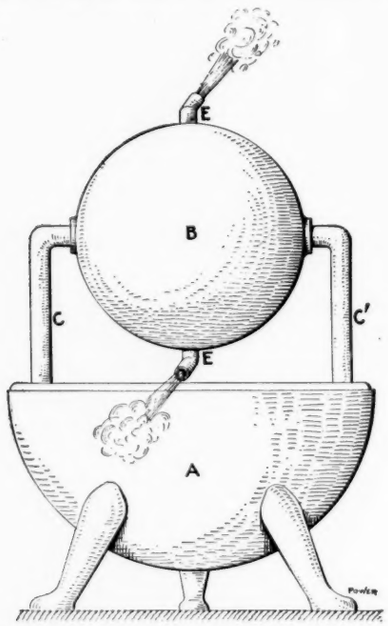


FIG. 2. HERO'S ENGINE. THE FIRST STEAM TURBINE

invented a form of steam pump, with which he hoped to overcome the difficulty.

A boiler *A*, Fig. 3, delivered steam through the pipe *B* to the cylinder *C*. When all the air in *C* had been displaced by steam, the valve in *B* was closed and the valve in *F* opened, permitting a stream from a reservoir *G* to be played into the cylinder. The water causing the steam to condense formed a partial vacuum, which was filled by water forced up by the air pressure through *D*. When the flow into the cylinder ceased, steam was again let into *C*, forcing the water up through *E*.

This engine, which was patented in 1698, met with little success because of the great pressure necessary to force the water to any considerable height in *E*.

At this time, Newcomen and Cawley, the one an ironmonger, the other a plumber, invented an engine on the theory of Papin (1690), who said that heating water in a cylinder would cause a piston to move out, when if the cylinder were cooled, the pressure of the air would push it in again. Newcomen and Cawley used this idea but made the steam outside. Fig. 4 shows the working parts of this engine. A boiler *A* furnishes steam for the cylinder *B*, which has a piston hung by a rod and chain from a beam *I*, the other end of which is attached, by means of a chain and rod, to the piston of a suction pump *C*. When the chamber *B* is filled with steam, the piston *E* is at the top. When water from *D* is sprayed into it, the steam condenses causing a partial vacuum

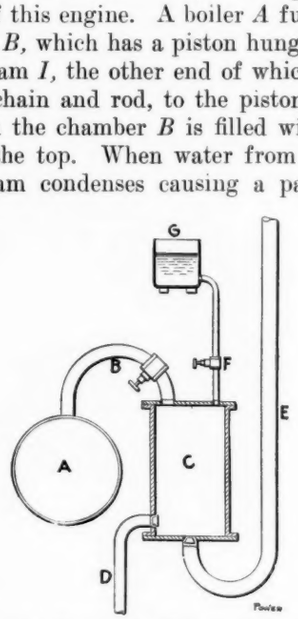


FIG. 3. SAVERY'S STEAM PUMP

and the weight of the air presses the piston down. *F* is an outlet pipe, which was opened occasionally to permit the water and condensed steam to run out of the cylinder. It had a valve opening outward so as to permit the water to run out, but kept the air from coming in during the down stroke of the piston.

Savery had a patent which gave him all rights to engines run by fire, so that Newcomen and Cawley went in with him. They erected one of these engines in 1712. The place of erection is unknown, but that it was in the year 1712 is undisputed.

These engines were more successful than those of Savery and were used in many mines, upon estates and, in some cases, to pump water for towns and to drain low lands. This engine did away with the great pressure necessary in Savery's engine, because they only needed enough steam to overcome the pressure of the air, and water could be pumped against considerable heads by using water pistons of comparatively small area.

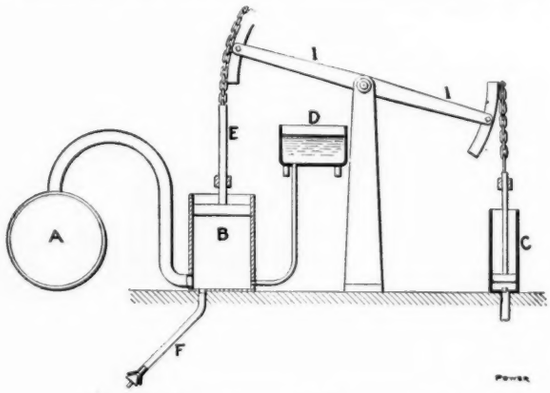


FIG. 4. NEWCOMEN'S PUMPING ENGINE

The first steam engine operated in America was one

of these Newcomen pumps, installed in 1753 at Schuyler's Point, on Newark Bay, in New Jersey by Josiah Hornblower.

The great trouble with this engine, from the engine boy's standpoint, was that he must stay and turn the valves on and off when he would rather be playing. One of these youths, Humphrey Potter is said to have devised a system of levers by which the engine worked them itself, but whether or not he was allowed to run and play or other work was found for him has not been recorded to the writer's knowledge.

This, then, was a practical steam engine, fifty years before Watt's, and 1912 passed by without any recognition of its bicentenary. It was while working upon one of these engines, at the University of Glasgow, that Watt became interested in them and his improvements followed. He found that if he used more water to condense the steam, he gained more power, but it took more fuel since he must reheat the sides of the cylinder. To overcome this, he condensed the steam in another cylinder or condenser. He also thought that steam could be used to better advantage than air in making the piston descend. He then made the engine double-acting.

This, then, is the history, in short, of the steam engine, and while we celebrate the centenary of the invention of Fulton's steam boat and the launching of the "Comet," we have let pass the true birthday of that great factor in the world's history, the piston steam engine.

The Joys of Monotony

That there is a mental monotony in the performance of the same operation day after day and year after year is denied by Prof. Münsterberg, the well known Harvard psychologist, who has made an interesting study of the subject and gives examples taken from an electric lamp factory.

It was Müsterberg's habit, when visiting a factory, to select what seemed to him the most tiresome job possible, and then study its effect upon the employee. The prize job appeared to be that of a woman who for 12 years had packed incandescent lamps in tissue paper. She packed on an average 13,000 lamps a day—about 25 lamps in 42 sec. And she denied its monotony. Her interest was held in what she called the continuous variation of the work, such as grasping the lamp or paper a different way, or studying the unevenness of the packing, or her mood for the work.

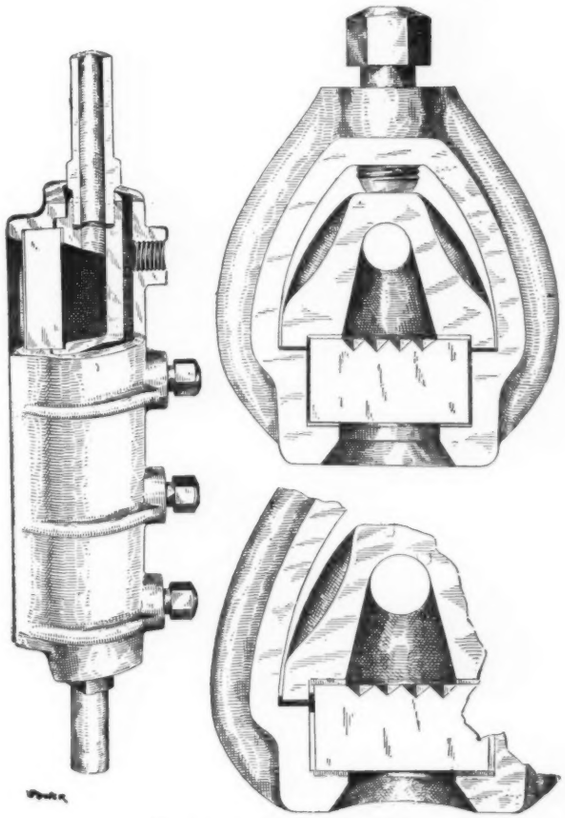
The *Bulletin* of the National Electric Light Association, from which this information is gathered, says that "even in the most uniform and stereotyped occupations, room is left for interest in the work, for thought, for self-sufficiency to a higher degree and, in almost every case, the chance of improvement in the means, the material, etc.

"In our central-station field, many of the younger men, and especially those who come into it without acquaintance with its history and evolution, seem to think that many of the tasks, and much of the work they do are monotonous; but they will not be much older before they discover that the monotony is superficial, the variety eternal. There is not one single thing in the central-station industry that cannot be done better, or made cheaper, or become more perfect or give fuller service than it does today, and in that way lies infinite opportunity for every one of us."

Klinger Water Glass

This glass consists of a brass body and a separate brass back piece, the latter including the steam and water cavity. The glass is held between these two parts and is gripped by pressure obtained by four setscrews, equally spaced on the back of the body. The general form and arrangement of this construction is shown in the illustrations.

Three gaskets have been introduced between the steam space and the face of the glass and so arranged that the steam must work by each successively before a leak can



KLINGER WATER GLASS

develop. The two gaskets on the front and back of the glass are of fiber $\frac{1}{32}$ in. thick and the construction allows a liberal width of seat on the metal. The third, a $\frac{1}{16}$-in. gasket of elastic material, is between a lip on the back piece and the main body, and comes at the side of the glass about one-quarter of the distance from the back. This is formed so as to seat against the glass, as well as between the lip on the back piece and the body.

Its elasticity is such as to permit any unevenness in the thickness of the glass to be compensated and give an equal pressure on the fiber gaskets at the top and the bottom throughout the full length, while, at the same time, the elastic gasket will also be steam-tight. The water shows black and steam white. The connections are of the proper size and form to permit of it being attached to a boiler without any changes in the fittings.

The Jerguson Manufacturing Co., 10 Post Office Square, Boston, Mass., is the manufacturer.

The world's wealth so far as expressed in stock-exchange securities is $115,800,000,000, in which the United States is represented by over twenty-five billion.

Reciprocating Pump Curves

By A. M. Daniels

SYNOPSIS—Description of the construction and use of curves for determining the size of reciprocating pumps required under given conditions.

❖

The curves of the accompanying diagrams have been constructed to facilitate determining the size of pumps necessary to fulfill certain requirements.

Method of Construction

In constructing the curves, reference has been made to numerous pump catalogs, and, since they show no great variation as to revolutions or double strokes per minute or in velocities allowed in the different pipe sizes, in some cases a mean value has been used.

Curve 1. Since 100 ft. per min. is generally considered a good mean value upon which to base capacity calculations, this curve has been laid down on that basis with abscissas as stroke of pump in inches (found at the top of the diagram) and ordinates as revolutions per minute or double strokes (found on the right of the diagram).

Curve 2. In studying the various pump catalogs, it was observed that for a pump of a certain diameter water cylinder, a certain stroke and a certain piston speed, if the stroke be increased for the same size water cylinder, the pump may then be run at a higher piston speed than was allowable with the shorter stroke. The pump makers claim that this is for the reason that it is not reversed so often. Therefore, Curve 2 has been plotted to read actual revolutions or double strokes for pumps of given strokes, the abscissas being strokes in inches (found at the top of the diagram) and ordinates being revolutions or double strokes (found at the right of the diagram).

Curve 3. Having plotted Curve 2 to agree with the pump makers' practice, Curve 3 has been laid down to show the corresponding actual piston speeds plotted from the equation, piston speed = 2 × r.p.m. × stroke (feet). The abscissas for this curve are strokes in inches (found at the top of the diagram) and the ordinates are feet per minute (found at the right of the diagram). This curve clearly shows the increased piston speed due to the stroke being lengthened. For example, suppose two pumps of the same water cylinder diameter, one with a 9-in. stroke and the other an 18-in. stroke. From this curve it is seen that for the 8-in. stroke pump, the piston speed would be 86 ft. per min., while the stroke of the 18-in. gives a piston speed of 120 ft. per min.

Curve 4. This curve is based upon a piston speed of 100 ft. per min. and corresponding capacities for different sizes of water cylinders, capacities being in gal. per min. The abscissas are diameters of water cylinders in inches (found at the bottom of the diagram) and the ordinates are gal. per min. (found at the left of the diagram).

Curve 5. This is a velocity curve and is based upon mean values of velocities in suction pipes in terms of their diameters. The mean values were estimated from the catalogs as velocity = 164 $\sqrt{D}$. Using this equation, the curve was plotted with abscissas as diameter of suction pipe (found at the bottom of the diagram) and ordinates as velocity in ft. per min. (found at the left of the diagram).

Curve 6. This also is a velocity curve and is similar to Curve 5. This curve gives velocities in the discharge pipe when the velocities are based upon the mean value, as derived, of velocity = 200 $\sqrt{d}$. The abscissas and ordinates are the same as for Curve 5.

Curve 7. Using the velocities in the suction pipe of 164 $\sqrt{D}$ and calculating the capacity in gallons per minute from the equation: quantity = area × velocity, this curve has been constructed with abscissas of diameters of suction pipes (found at the bottom of the diagram) and ordinates of gallons per minute (found at the left of the diagram).

Curve 8. Using the velocities in the discharge pipes of 206 $\sqrt{d}$ and calculating capacities as for Curve 7, the construction of this curve is similar to the construction of Curve 7.

Application of the Curves

Example 1. *Knowing the stroke and diameter of a water cylinder to find the capacity.* If a 16-in. stroke pump with a water cylinder 7 in. in diameter had a piston speed of 100 ft. per min., we could obtain the capacity directly from Curve 4 by reading the capacity of a 7-in. diameter as 200 gal. per min. But this is not correct as Curve 3 shows that for a 16-in. stroke pump the piston speed, instead of being 100 ft. per min. is 113.3 ft. per min., and since

$$\frac{\textit{Actual piston speed}}{\textit{Piston speed 100 ft. per min.}} = \frac{\textit{actual capacity}}{\textit{capacity for 100 ft. per min.}}$$

then for this case we should have

$$\frac{113.3}{100} \times 200 = 226.6 \textit{ gal. per min.}$$

To determine the diameter of suction pipe, Curve 7 is referred to and for 226.6 gal. per min. the diameter is found to be 4¼ in. Similarly, the discharge pipe is found from Curve 8 to have a diameter of 3¾ in. (In reading pipe sizes the nearest ¼-in. pipe size larger than shown where the curve cuts the line is taken.) The corresponding velocities in these pipes will be obtained from Curve 5 for the suction and Curve 6 for the discharge. For the 4¼-in. suction pipe there is found a velocity of 340 ft. per min. and for the 3¾-in. discharge pipe a velocity of 405 ft. per min.

Example 2. *Knowing the capacity required, to find the size of the cylinder and other quantities.* Suppose the pump must deliver 500 gal. per min. First, the stroke must be assumed. This may be fixed by conditions of usual practice. Assuming a stroke of 8 in., if the piston speed were 100 ft. per min., Curve 1 shows that the pump would have to run at 75 r.p.m., but to determine the revolutions corresponding to those actually allowed, Curve 2 shows, for an 8-in. stroke 60 r.p.m. and Curve 3 an actual piston speed of 80 ft. per min.

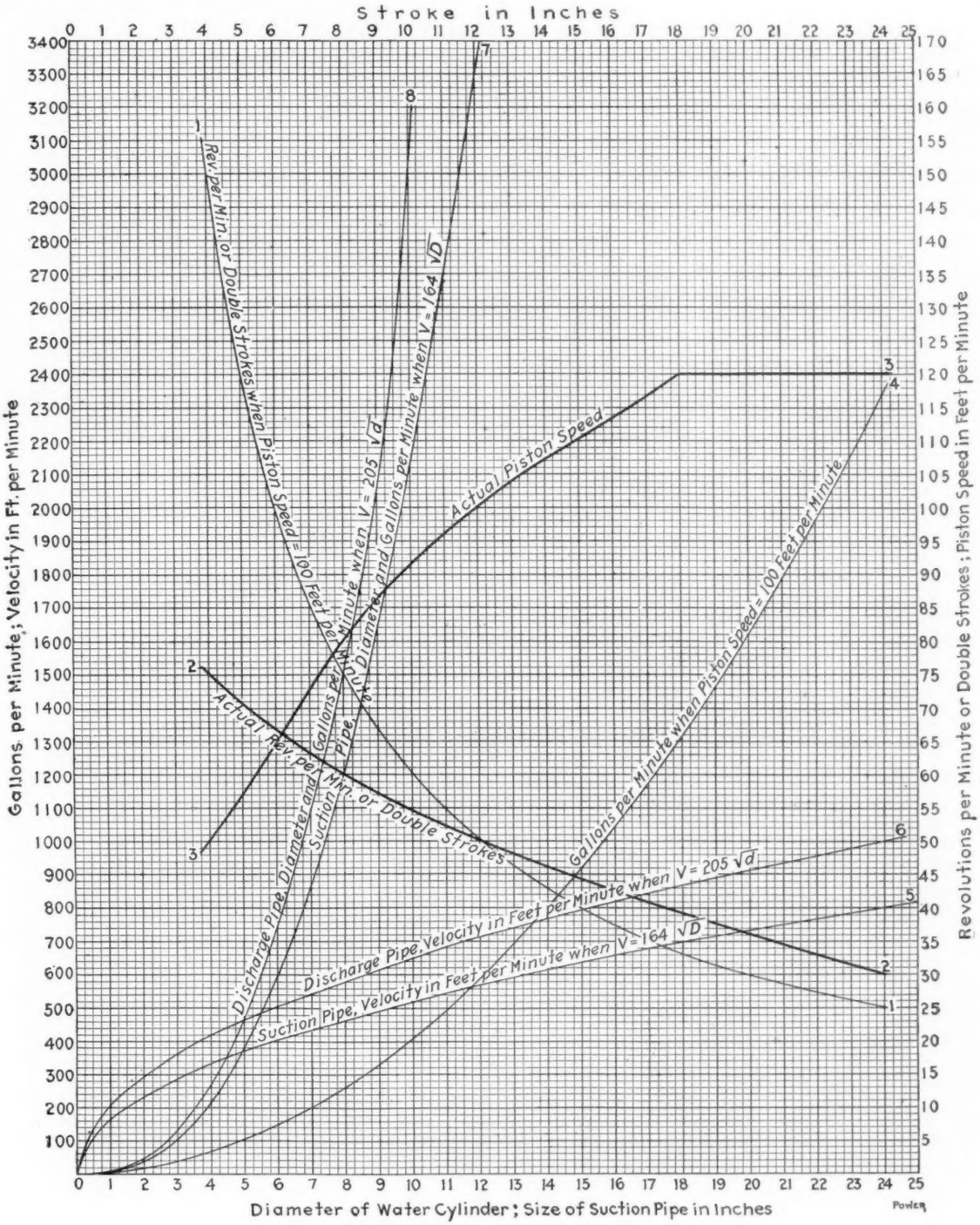
The next step is to determine the size of the water cylinder. For a piston speed of 100 ft. per min., from Curve 4, corresponding to 500 gal. per min., the diameter indicated is 11 in. This is not correct though, for this pump is to run at a piston speed of only 80 ft. per min., therefore, to deliver 500 gal. the cylinder must be larger than 11 in. and, since for a given capacity, the cross-sectional area or square of the diameter must vary inversely as the

piston speed, i.e., the square of the diameter should = 11 $\times$ 11 $\times$ $\frac{100}{80}$; , and the cylinder diameter would be

$$\sqrt{11 \times 11 \times \frac{100}{80}} = 12.29$$

or about $12\frac{5}{16}$ in.

Having the capacity, the diameters of suction and discharge pipes and respective velocities may be obtained as in Example 1.


Stroke in Inches
Gallons per Minute; Velocity in Ft. per Minute
Revolutions per Minute or Double Strokes; Piston Speed in Feet per Minute
Diameter of Water Cylinder; Size of Suction Pipe in Inches
Rev. per Min. or Double Strokes when Piston Speed = 100 Feet per Minute
Actual Piston Speed
Actual Rev. per Min. or Double Strokes
Gallons per Minute when V = 205 √d
Diameter and Gallons per Minute when V = 164 √D
Gallons per Minute when Piston Speed = 100 Feet per Minute
Discharge Pipe, Velocity in Feet per Minute when V = 205 √d
Discharge Pipe, Velocity in Feet per Minute when V = 164 √D
Suction Pipe, Velocity in Feet per Minute when V = 164 √D
Discharge Pipe, Diameter and Suction Pipe
Power

EXAMPLE 3. *Knowing the cylinder diameter and stroke, to determine the capacity for any other stroke.* Having a pump of 7-in. water cylinder, with a stroke of 18 in., what will be the capacity if only a 9-in. stroke is used?

First of all, Curve 2 shows that having an 18-in. stroke, the pump must make 39 r.p.m., and have a piston speed, Curve 3, of 120 ft. per min. Curve 4 gives a capacity for a 7-in. cylinder and 100 ft. piston speed of 200 gal. per min.; but since this piston speed is 120 ft. per min., the capacity must be increased in the ratio of 120 to 100, or capacity = 200 $\times$ $\frac{120}{100}$ $\times$ 240 gal. per min. But Curve 2 shows that if the stroke is shortened to 9 in., the pump must be run at 57 r.p.m. and then have a piston speed of about 86 ft. per min. Consequently, the capacity of 200 gal. per min. will be decreased in the ratio of 86 to 100, or capacity = 200 $\times$ $\frac{86}{100}$ = 172 gal. per min., i.e., a difference of 68 gal. per min. in favor of the longer stroke with 18 less r.p.m.

ELECTRICAL DEPARTMENT

Three Wire System with Rotary Balancer

By A. M. Bennett

The advantages in the use of the direct-current, three-wire system are well known, and have led to its general adoption for the transmission and distribution of electrical energy from central stations, as well as in connection with the isolated-plant service. In fact, there is no class of service having a fairly well divided lighting and power load, in which this system cannot be economically and effectively employed. The two voltages existing on the system, usually 110 and 220, meet the requirements of lighting and power service respectively in an ideal manner, inherent characteristics of lamps requiring a low voltage, while motors work equally as well on the higher

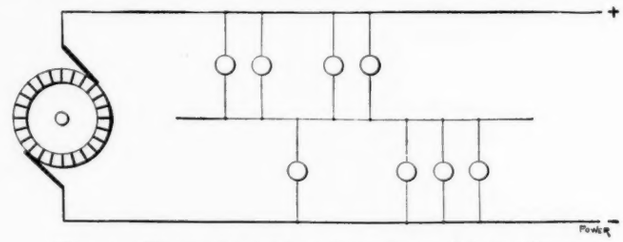


Fig. 1. Possible Arrangement if Load Were Always Balanced

voltage, and in the larger outputs will be found to cost materially less. The combination affords a convenient means of operating variable-speed motors on a two-voltage system, the motors being connected across the outer mains, their low-voltage connection being made to the neutral.

However, it is the saving in line copper by the use of the three-wire system that is the chief factor responsible for its promotion and extension, this saving being due to the fact that the energy, although used at the lower voltage, is transmitted at the higher. In a two-wire system this energy would have to be transmitted at the voltage at which it was used, which to correspond to that of the three-wire system, would be the lower voltage. In this case, therefore, with the same output, the current flowing would be twice that in the former case. As the line loss in watts equals the square of the current multiplied by the line resistance, it is evident that with a given loss, the resistance in the former case can be four times that in the latter, or the weight of copper one-fourth. This takes account of two mains only in either system. In a three-wire system the middle wire or neutral as it is called need be only large enough to carry the unbalanced current, which varies in different installations from 10 to 25 per cent. of the total load. Figuring liberally for the neutral wire by making it one-half the size of the outside mains, the weight of copper in the three-wire system becomes five-sixteenths that in the corresponding two-wire system, with the same line loss in each case.

If the load on a two-wire system were such as to be always divisible into two equal groups, the apparatus comprising this load could all be of the lower voltage, and the two groups connected in series across the mains of a system generating the higher voltage, with a third line connecting the inside ends of the individual loads, as shown in Fig. 1; this would serve to distribute the current from one load group to the other. Such an arrangement would permit advantage to be taken of the low voltage for lamps, and of the higher voltage for distribution, with its consequent saving in copper, and would insure a voltage balance on the two sides of the system as long as the resistance of the combined load on each side remained the same. Where there is a divided load, however, it is impossible to proportion and control this so exactly, that at all times there is the same load on each side. In the scheme shown by Fig. 1, if the resistance on one side of the system changes, due to switching off part of the load, the combined resistance of the two sides also changes, and with it the current flowing through the connected apparatus. But, inasmuch as the groups on the two sides are in series, the same current must flow through each, irrespective of the fact that under the changed conditions, the amount of current required by the two groups will be different.

For example, consider eight 25-watt, 125-volt lamps connected across 250 volts, as in Fig. 1. The resistance of each lamp is approximately 625 ohms, and their combined resistance is

$$\frac{625 \times 2}{4} = 312.5 \text{ ohms}$$

This across 250 volts, gives rise to a current of 0.8 amp.,

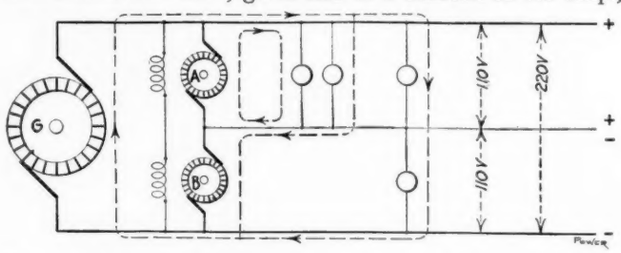


Fig. 2. Showing Distribution of Unbalanced Load

and as there are four paths in multiple, each consisting of two lamps in series, each path will take 0.2 amp., which is the normal current for such lamps.

Now consider the effect of turning off a lamp on one side of the system. The combined resistance of the remaining seven will be

$$\frac{625}{4} + \frac{625}{3} = 364.6 \text{ ohms}$$

which at 250 volts allows approximately 0.68 amp. to flow. As this divides among four lamps on one side, each must take 0.17 amp., or 85 per cent. of its normal current. On the other side each lamp will take one-third of the total current flowing, or approximately 0.23 amp., which is 15 per cent. in excess of normal current. Neither

set of lamps is burning under normal conditions, nor can the voltage on the system be raised to allow more current through the dimly burning lamps, without correspondingly increasing the current taken by those that are already burning too brightly. It is necessary, therefore, to so arrange the source of power, that a voltage of one-half that between the outside mains be provided for the third wire, in order that the load on one side may be independent of that on the other. In other words, the load on each side must be at an independent voltage. To this end various methods have been devised, of which two only are in general use at present; these are the three-wire generator,* and the rotary balancer.

The rotary balancer in its most common form consists of two like machines with their shafts coupled together, and their armatures connected in series across the mains of an ordinary two-wire system, as in Fig. 2, where *G* represents the main generator, and *A* and *B* the two machines comprising the balancer. Each of the latter is wound for one-half the voltage of the main generator, and their combined rating in amperes is made equal to the probable difference in load between the two sides of the system. This is known as the unbalanced load, which is carried by the neutral wire, taken off from the balancer at the point where the two armatures connect.

Of course, it will be understood that apparatus designed for the voltage between the outside mains, can be connected across these mains, without affecting in any manner the unbalanced load of the system.

The action of the balancer is as follows: When the load on the system is balanced, that is, the same on both sides, the two machines run as motors in series across the outside mains. No work is done, and no current is used except that necessary to overcome the losses of the machines running free. As soon, however, as one side of the system becomes more heavily loaded than the other, this action of the balancer ceases. The drop in voltage on the side having the heavier load will be the greater, and the voltage impressed on the machine on this side will be reduced. The machine connected across the lighter loaded side, having the higher voltage, will now tend to run faster than the other, and drive it as a generator. The motor will act as a load on its side of the system, lowering the voltage on that side, while the generator will supply current to, and raise the voltage on the heavily loaded side. The combined current of the two machines is equal to the unbalanced load of the system, and the effect on the voltage is to restore the balance.

As the unbalanced load may shift at any time from one side to the other, it is evident that this action of the balancer must also shift. Either machine may at one instant be operating as a motor, and at the next as a generator. As the direction of rotation is always the same, it is impossible at any time to tell, without knowing how the load is balanced, which is the motor, and which the generator.

It is usual in speaking of the current in the balancer, to say that one-half the unbalanced load is taken by each machine. This would be true if no losses existed in the machines. As these losses must be supplied by the motor, the actual division of current is such, that that taken by the motor is in excess of that in the generator by the amount of the losses in the two armatures. This division of current can best be shown by an example, and for simplicity the losses in the two machines will not be considered. In Fig. 3 with ten, 60-watt lamps on the positive side and six on the negative side, the total load on the main generator is

$$\frac{16 \times 60}{240} = 4 \ amp.$$

This is the current going out at the positive brush, and returning by the negative. The load on the positive side is

$$\frac{10 \times 60}{120} = 5 \ amp.$$

and that on the negative side is

$$\frac{6 \times 60}{120} = 3 \ amp.$$

The unbalanced load is 2 amp. Therefore, *B* will run as a motor, drawing its power from the main generator, and will drive *A* as a generator, which in turn will furnish current to the heavily loaded side. The current in each machine will be 1 amp., that is, the unbalanced load is divided between the two machines. The one ampere taken by the motor is added to the 3-amp. lamp load on that side, making the 4 amp. furnished by the main generator. These 4 amp. have added to them the 1 amp. furnished by the generator half of the balancer set, making the 5 amp. required on the positive side of the system.

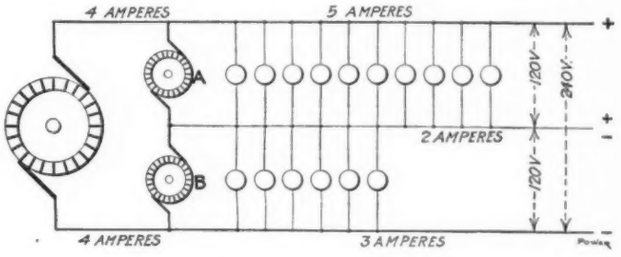


FIG. 3. UNBALANCED LOAD

The direction of current flow with unbalanced load can be seen from inspection of Fig. 2, being shown by the arrows on the dotted lines.

Balancer sets may be either shunt or compound wound. A common method of connecting a shunt-wound balancer is shown in Fig. 2, the fields of the two machines being in series across the mains of the system. In this case both machines have the same field strength, and the counter electro-motive force generated by each is the same. The regulation is poor, due to the drop in speed of the motor with increasing load, and for this reason this method of connection is not to be recommended.

Regulation in a shunt-wound balancer may be improved by crossing the fields, and connecting their middle points to the neutral, as in Fig. 4. This puts the motor field across the voltage on the generator side of the system, and the generator field across that on the motor side. With a balanced-load condition the effect of this method is no different to that of the straight connection shown in Fig. 2, but with an unbalanced load the motor field, being subjected to the lower voltage of the generator side, is weakened, the speed of the set is raised, and with it the voltage of the generator. This latter effect is still further increased as the fields of the generator are

*The three-wire generator was fully discussed in an article by the author in the Oct. 8, 1912, issue.

strengthened at the same time by being connected across the side of the system with the higher voltage.

Even with the increase of voltage thus obtained the voltage unbalance on the two sides of the system is not fully compensated for, and resort must be had to other means to raise the generator voltage with an increasing unbalanced load. This can be done by the addition of a series winding to the field of each machine, which must be connected so that in the motor it opposes the shunt field, and in the generator strengthens it. As the unbalanced load then becomes greater, and with it the drop in voltage on the heavily loaded side, so the effect of these series windings becomes greater. The motor field is weakened, and the speed increases as in the case of the shunt balancer just described. This combined with the strengthening of the generator field, raises the voltage of the generator, compensating for the increased voltage drop on the system.

There are various methods of connecting the series windings into the circuits of the system, the most widely used of which are shown in Figs. 4, 5 and 6.

In Fig. 4 these are shown connected in the neutral circuit. The same current flows through each winding, and the weakening effect on the motor field is the same as the strengthening effect on the generator field. The operation of the set is very stable under all conditions of load.

The connection shown in Fig. 5 where the series winding of each machine is in the armature circuit, is open to the objection that with increasing load the operation of the set becomes unstable, due to excessive field weakening of the motor. In this case the same current does not flow through both windings, as the neutral current divides on reaching the balancer, the larger portion passing to the motor as previously explained. The differential effect on the motor field is, therefore, greater than that in the preceding case, and its field flux is decreased at a greater rate than the generator flux is increased. This action becomes aggravated on overload, and the result is excessively high speed with poor regulation.

By crossing the series fields, as in Fig. 6, this objection is overcome. The motor current passes through the generator field, and the generator current through the motor field. Hence, the compounding effect of the generator field is greater than the differential effect of the motor field, due to the larger current passing through the former. The necessary voltage balance is obtained, therefore, with less speed increase, and the action of the set becomes even more stable than in the case of Fig. 4.

Where only one balancer set is to be used, a single regulator in the shunt field circuit of one of the machines, as at *R*, Fig. 4, will suffice for adjustment of the voltage. But if two or more sets are to be operated in parallel, each should be provided with two regulators to properly adjust the voltage. These should be connected as in Fig. 5, or a three-point regulator may be used, as in Fig. 6. This latter is preferred, as manipulation of one rheostat is easier than two. Adjustment by rheostat is made under no-load condition. If further adjustment is necessary under load, it should be done by shunting part of the current from the series windings.

A starting rheostat connected in the armature circuit of one of the machines permits the set to be started and brought up to speed.

A form of balancer sometimes used where the load to be taken care of is small, consists of a machine, the armature of which has two like windings, each connected to its own commutator. This rotates in a single field. On this account voltage adjustment by field regulator is not possible, as the same field flux affects both armature windings alike. A series winding is not of use for the same reason. It can be readily seen that, due to lack of voltage adjustment and compounding, regulation with this arrangement will be poor.

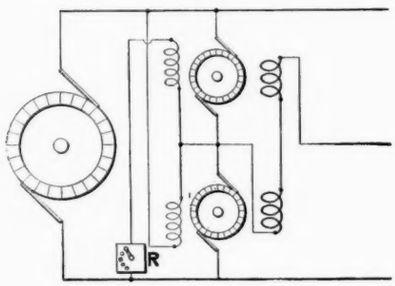


FIG. 4

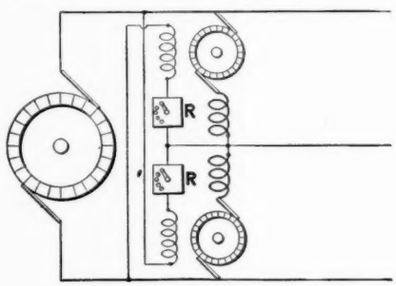


FIG. 5

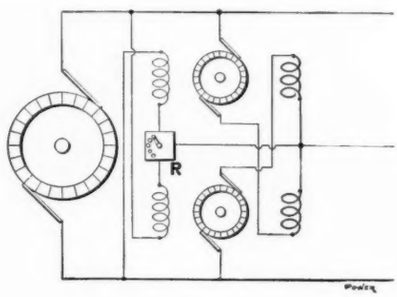


FIG. 6

VARIOUS FIELD CONNECTIONS FOR REGULATION IN COMPOUND-WOUND BALANCER

The switchboard equipment for balancer sets, in addition to the starter and regulator previously mentioned, usually consists of a double-pole and a single-pole switch, and a central zero ammeter. A voltmeter switch may be provided by means of which the voltage across the outside mains of the system, and also between either main and the neutral may be read from the voltmeter on the main generator panel. The double-pole switch is placed in the lines connecting the set to the mains of the system, and the single-pole switch in the neutral.

If a protective device, such as a circuit-breaker, is used in the neutral, it should be arranged to also trip the main generator breaker. Otherwise, if from overload on the neutral or a short-circuit, this breaker should open, the lamps on the system would be thrown in series across the outside mains, and they would burn out before the neutral circuit could again be established. Such a device in addition to the protection it affords the load on the system, is also a safeguard to the balancer set. For the reason just stated fuses should not be used in the neutral, unless they are of a capacity to withstand any probable overload on this circuit.

For individual feeder circuits, three-pole switches are all that is required, though in many cases three-pole circuit-breakers are used, with a coil in each outside wire. These connections are shown in Fig. 7.

In starting up the balancer, the neutral switch and those to the feeder circuits should be open. The double-pole switch should then be closed and the set brought up to

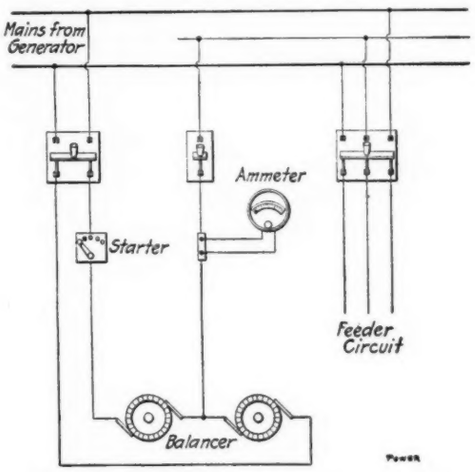


FIG. 7. SWITCHBOARD CONNECTIONS FOR BALANCER SET

speed by means of the starter. The neutral switch can then be closed, and after it, the various feeders can be connected to the main circuit.

Mr. Bryant's Motor Trouble

In regard to Mr. Bryant's inquiry in the Feb. 25 issue, I would say that it is indeed a peculiar case of motor trouble. He states that, although the motor does not work properly, each separate part is in good condition and as it should be, with the exception of a 20-volt ground which, however, he does not believe to be the cause of the trouble.

A ground of 20 volts on one phase only, will not interfere with the working of an induction motor, as I have known motors to carry a full load with a ground on one phase equal to the rated voltage of the motor.

Mr. Bryant's statement, "The stator windings had just been renewed and the cross-connections were made in accordance with the manufacturer's drawing for Y-wound motors of this type" is not quite clear. It may be that he used a drawing for Y-wound motors of that type, but that the drawing was not for that particular motor. The term Y-wound is rather indefinite as it may mean either a one-circuit Y or a two-circuit Y connection. All motors of the same type and number of poles do not have the same coil connections as the voltage also has to be considered.

I would suggest that a drawing of the coil connections for that particular motor be procured from the manufacturers (giving them the motor number, r.p.m., type and voltage) and then see if it compares with the way the motor is connected at present.

If the supply voltage and frequency corresponds with that called for by the nameplate, and the motor is not overloaded, the cause of its not coming up to speed and heating would very likely be due to excessive friction in the motor itself or to improper coil connections. As the coils have just been renewed and reconnected, it would seem quite probable that the trouble is in them.

L. H. HOLTZAPPLE.

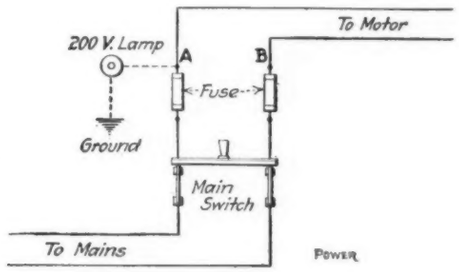
Winona, Mich.

Induction Motor Refused to Start

A 7-hp., 400-volt induction motor, working on a 40-volt, single-phase, 3-wire system with a grounded neutral refused to start one morning. I first tested at *A* and *B* through a 200-volt lamp to earth, the lamp lighting on each side which showed conclusively that current was on.

Next, I searched for loose connections, but could find none, and as a last resort grounded one side at the fuse and tried the motor at 200 volts between the outer line *A* and the earth. The result was that the motor started slowly and after a considerable time, in comparison with that usually required for starting, ran up to speed but stopped as soon as any load was put on.

This gave a clue to the trouble and to verify it I put



MAIN SWITCH AND FUSES

two 200-volt lamps in series across *AB*, and no light showed, there being no voltage between the mains, although each showed 200 volts to earth; this proved that *A* and *B* were of the same polarity.

There had been extensions to the mains just previous to this and a mistake had been made in connecting up, both the outer wires being put in parallel. The lighting being on the 200-volt circuit remained unaffected as there were 200 volts between the outer wires and the neutral.

L. H. FIELD.

N. Adelaide, Australia.

Charging Dry Batteries

In the Feb. 18 issue, Mr. McGerry describes a method of recharging dry batteries. During the past week I have tried out some 25 batteries as per the directions given, taking care to follow them very carefully. I was able to get as high as 12 amp. out of one and lower readings out of the rest, but after allowing the batteries to stand 10 to 12 hr. they were as dead as ever.

I would like to inquire if Mr. McGerry used any acid or other material in the water with which he soaked his batteries. Possibly he may be able to give some reason why all the batteries failed to resurrect themselves. I made a very careful inspection of the zinc covers before attempting the experiment.

R. S. KING.

Ellendale, N. D.

In a recent issue we mentioned an instructive little device called the "Current-O-Scope" which Fairbanks, Morse & Co. were distributing for 25c. apiece. Our readers will be interested to know that the above company has now decided to send these to engineers, free of charge, in return for information regarding the equipment under their care.

GAS POWER DEPARTMENT

Jacket Water Requirements of Internal Combustion Engines

By Reginald Trautschold

Tests and practice have indicated that a well designed internal-combustion engine operates most economically when its jacket water is discharged at the highest temperature attainable without serious generation of steam in the engine jackets, a temperature of about 185 or 190 deg. F.; also, that the temperature of the jacket-water supply has little effect upon the fuel consumption of the engine provided a difference of at least 105 deg. is maintained between the temperatures of the incoming and the outgoing water. To maintain a suitable temperature of discharge, then, the quantity of water supplied to the jackets and the temperature at which it is admitted are the two governing conditions.

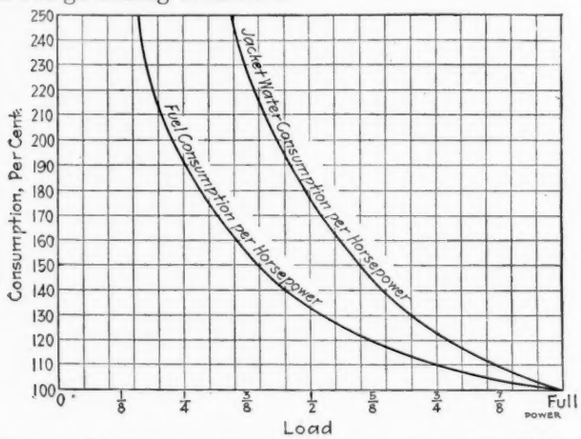


Fig. 1. Effect of Load on Fuel and Jacket-Water Consumption

Considering first the consumption of jacket water, not only does the load on the engine affect the quantity required, but the efficiency of the engine under the load must also be taken into consideration. Considering both fuel and jacket-water requirements as unity at full load, when the engine operates at its best efficiency, the increase in fuel and jacket-water requirements for the best results in a typical case are given in Table I, which is graphically shown in Fig. 1. At three-eighths load, about the lightest load that an engine in an efficient installation is called upon to carry, the fuel requirements per horsepower are 54.5 per cent. greater than when operating under full load, while the jacket-water requirements are 2.85 times as great as under the more efficient operation. This relation is about constant regardless of the temperature of the water fed to the jackets, provided it is not much more than 80 deg. F. above which temperature of supply the generation of steam in the jackets commences to become serious before the efficient temperature ranges of 105 deg. is attained, resulting in reduced jacket efficiency and a corresponding increase in fuel consumption.

The temperature of the water supply to the jackets has an effect, however, upon the consumption of jacket water, for the cooler the water the longer it can be retained in the jackets, water of a higher temperature reaching the advisable temperature of discharge through a lesser temperature range. The minimum practical temperature of the jacket-water supply is about 35 deg. F. while its maximum temperature is about 80 deg. Considering the required quantity of jacket water at an entering temperature of 35 deg. as unity, the quantity of jacket water required at other temperatures of supply and under various engine loads is given in Table II. In installations where the jacket water is used over and over, the rate of consumption is of secondary importance as, within reasonable limits, this simply necessitates increasing or decreasing the mean velocity of the water through the jackets. Where water is sufficiently cheap to permit its being wasted, the supply temperature is usually relatively low and the saving that accrues from low temperature of supply may or may not be sufficiently great to take into consideration. The former practice, that of cooling the water and using it over again, is the more common and, as the rate of consumption is of little importance, the effect of supply temperature on the consumption of jacket water is of interest. Considering the requirements at full load as unity, this relation is graphically shown in Fig. 2, and, although little difference in the requirements of an engine operating under at least ⅞ load is noticeable, there is considerable variation between ½ and ⅜ load. From full load to ⅜ load the increase in jacket-water consumption, with water supplied at 35 deg., would be 173.5 per cent. while in the case of jacket water supplied at 80 deg. the increase for the same range in load would only be 122 per cent.

The jacket-water requirements in gallons per horsepower at various loads and supply at temperatures for an efficient oil engine are indicated in Fig. 3; also, this may be taken as typical of internal-combustion engines operating on any fuel. A fuel low in heat value, such as ordinary city gas and producer gas, requires more jacket

TABLE I. EFFECT OF LOAD ON FUEL AND JACKET-WATER CONSUMPTION

Load	Consumption per Horsepower	
	Fuel	Jacket Water
Full	1.000	1.000
⅞	1.048	1.099
¾	1.108	1.232
⅝	1.200	1.440
½	1.325	1.765
⅜	1.545	2.850

TABLE II. EFFECT OF SUPPLY TEMPERATURE ON JACKET-WATER CONSUMPTION

Temperature of Water Supply	Quantity of Jacket Water Required at Various Loads					
	Full	⅞	¾	⅝	½	⅜
35 F.	1.000	1.135	1.313	1.598	2.041	2.735
40	1.030	1.165	1.343	1.628	2.071	2.765
45	1.067	1.202	1.380	1.665	2.108	2.802
50	1.108	1.243	1.421	1.706	2.149	2.843
55	1.151	1.286	1.464	1.749	2.192	2.886
60	1.198	1.333	1.511	1.796	2.239	2.933
65	1.245	1.379	1.558	1.843	2.286	2.980
70	1.295	1.429	1.609	1.893	2.336	3.030
75	1.353	1.487	1.667	1.951	2.394	3.088
80	1.422	1.556	1.736	2.020	2.463	3.157

water for power developed than richer fuels, but the effect of load and jacket-water requirements on fuel consumption is about the same. In any event, the importance of carefully regulating the jacket-water supply to conform with the engine load is evident, for the temperature range of the jacket water is directly dependent upon its supply.

In installations where the cooling jacket water is used repeatedly, there is no appreciable gain in reducing the temperature of the supply to much below 80 deg. F. In fact, at this temperature there is an advantage, other than that of reducing the cooling facilities that must otherwise be provided; for, the supply of jacket water when the engine is operating under light load does not have to be relatively increased as much as when the water supply is cooler, facilitating regulation, or rather minimizing losses in efficiency should the regulation not be sufficiently sensitive. In installations where the jacket water is wasted, the supply may be advantageously as near 35 deg. as possible and thus decrease the consumption, even though the relative increase in jacket-water

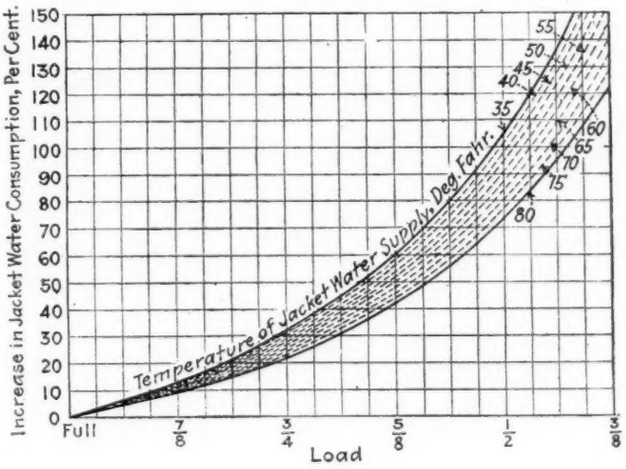


FIG. 2. JACKET-WATER REQUIREMENTS AT DIFFERENT LOADS AS DEPENDENT ON TEMPERATURE OF SUPPLY

requirements from full to light loads is greater and the regulation, therefore, necessarily more sensitive than when using warm water.

Accurate hand regulation of the water supply to the jackets is naturally difficult and in many installations automatic regulators can be advantageously installed. The saving in fuel consumption that is possible through the use of such controllers or regulators depends, of course upon the variations in engine load and upon the attention of the operating engineer to the jacket temperatures without such automatic devices, a fairly constant load, and careful engineers discounting the value of a jacket-water controller as a money saver.

❖

In the "London Times," C. E. Stromeyer, chief engineer of the Manchester Steam Users Association, gives the following table as showing the prices of the various fuels. Each column gives those prices at which equal economy could be had if any of the power processes mentionad are used:

Fuel	Prices per Ton					
Crude oil for Diesel engine ..	$8.52	$9 73	$10.95	$12 17	$1314..39	$60
Gasoline for gasoline engine .	10.70	12 17	13 63	15 09	16.79	18.25
Coal for producer-gas engine..	2.79	3 25	3 65	4.02	4.50	4 87
Coal for gas-fired boiler.....	2.07	2.31	2.56	2 92	3.16	3.41
Coal for steam engine..... ..	2 43	2.92	3.29	3.65	4.02	4.38

Removing Piston Rings

BY A. L. BRENNAN, JR.

It is invariably found that unless proper precautions are taken in removing piston rings that the operator will be confronted with one or more broken rings. This is because the rings are of cast iron, which is limited in elasticity; consequently care must be taken not to "spring" the rings too much when opening them to clear the grooves. Piston rings that have become badly gummed, due to faulty lubrication and fit tightly in their grooves or are rusted in, will need particular attention. In this case it is always advisable first to soak the piston in kerosene for a few hours. This softens the carbon or rust and frees the rings; but if the pistons are in a particularly bad condition it may be necessary to pound the rings loose—an operation which should be performed only with a wooden or lead hammer. Never hit a piston or ring with a steel hammer; however, a piece of wood may be placed against the rings and the wood tapped with a hammer.

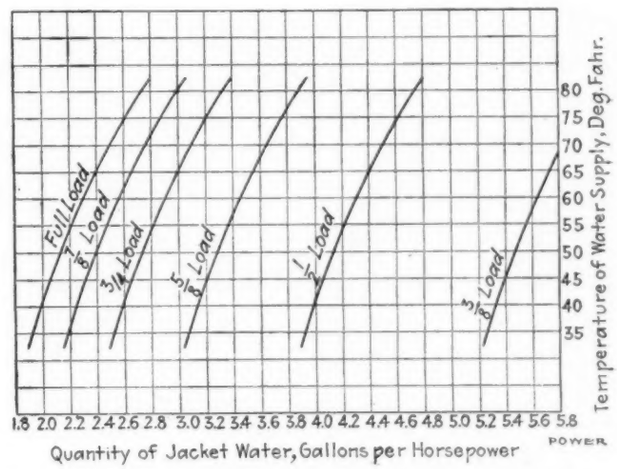


FIG. 3. EFFECT OF WATER-SUPPLY TEMPERATURE ON JACKET-WATER REQUIREMENTS

After the rings have been soaked in kerosene or otherwise freed of excessive carbon so that they work freely in their grooves they will be ready for removal. Usually about the only tool an operator has at hand that will help in the removal of the rings is a screwdriver; except in rare instances this is sufficient when used in conjunction with three or four strips of tin or sheet iron, the number and size depending upon the size of the piston. For small motors strips of tin as long as the piston and from ¼ to ½ in. should be used as follows: The ends of the top ring should be worked apart by gently forcing the end of the screwdriver into the "cut"; when this is done one side of the ring will lift and at this point one of the strips of tin should be inserted, then by following the tin with the screwdriver, the tin can be worked around until it is 180 deg. from the cut. It is not well to pry up the end of the ring at the "cut" far enough to clear the center of the ring, for in all probability this will snap off a piece of the ring. After the first strip of tin or iron is in position the same steps should be followed when inserting the other strips which should be placed at 90 deg. apart when four are used, or 120 deg. apart when three are employed. When the

strips are all in position the ring will have been elevated from its groove and can easily be removed, the strips of tin not only holding the ring out of its groove but acting as guides as well.

The most convenient way to handle a piston when removing the rings (if the piston is free from the engine) is to have it securely clamped in a vise, this will usually call for the piston being in an upright position; the jaws of the vise being in contact with the connecting-rod. In this case it is advisable to remove the lowest ring first, for, otherwise, difficulty may be experienced while removing these rings last, as they would have a tendency to drop into the grooves of the other rings should the guide strips slip.

After removing the rings they can be easily cleaned with emery cloth. The grooves in the piston should be looked over and any deposits removed by employing long, narrow strips of emery cloth.

When replacing the piston rings it is advisable to place the top ring in position first then the next and so on. By using the strips of tin as guides when putting the rings back little trouble will be experienced. After the rings are in place make sure that their joints are equal distances apart, for instance, if there are three rings on the piston, have their ends 120 deg. apart, or, if the piston has four rings, see that they are 90 deg. apart. Nearly all piston troubles can be avoided by suitable lubrication, that is, by employing an oil of the proper flash point, good viscosity and using about the correct amount.

Kerosene is very good for softening carbon deposits and limbering up the rings, but in most cases it is necessary to use it two or three times to get the best results. Never pour kerosene into the cylinders of a gas engine while the engine is hot, but wait until it has cooled off, for, if the oil comes in contact with the overheated metal, it will lose some of its valuable cleansing properties. After pouring about a pint of oil into each cylinder, crank the motor over several times to insure its distribution and then allow the motor to stand eight or ten hours. If this is carried out for three or four successive days, even if the motor is operated in the meantime, considerable good will result. This has reference to rings and pistons that are in bad condition. When a motor is in good condition, this should be resorted to about once a month, and in consequence it will seldom be found necessary to remove the rings.

New Oil Turbine

The English press has recently contained accounts of a new turbine of the internal-combustion type fed with oil. It is a double-flow turbine of the Parsons type, with a single admission port at the center, through which compressed air is forced at a pressure of about 960 lb. per sq.in., and at a temperature of about 1200 deg. F. Oil is then sprayed in, and burns, and immediately a spray of hot water (derived from the jacket of the last cylinder of the three-stage air compressor) follows, being at once converted into steam at high pressure; this expands through the blading in the usual way. Owing to the use of steam, the temperature in the blading is kept down, thus avoiding the troubles incidental to the exposure of the blades to excessive temperatures; in fact, the turbine has to be lagged to prevent loss of heat. The action, it will be seen, is not quite continuous, but is nearly so. The inventors are Messrs. Gavan and Leon Inrig, who have built a 65-hp. turbine of this type, running at 4000 r.p.m.

CORRESPONDENCE

An Operator's Experience with Diesel Engines

In talks with engineers regarding a change from steam to gas or oil engines, I find that the chief objection is that they are afraid the more complicated mechanism of these newer types would be too hard to learn, and that their positions would thus be endangered. My experience has been, however, that there is really but one thing to keep in mind in operating a Diesel engine and that is cleanliness; from this all the other necessary precautions follow. In wiping and polishing, one will discover nuts that have become loosened by vibration, which can be set up before any damage is done. The strainers should be cleaned once a week, which can be done while running, and I have found that the crank brasses on the engine I am operating need setting up every six weeks. The fuel nozzles show, after six months, no sign of wear. The atomizer needs cleaning every three months. In fact, dirt is the chief enemy of the Diesel engine.

The next one we order, however, will be under slightly different specifications, and here is where the prospective buyer may benefit by our experience. We shall specify that the side doors be made of aluminum, so that one man may handle them easily; that the studs holding the needle-valve gland, and the ears of the gland itself, be made heavier; that the back or piston end of the needle valve have some sort of hook or eye-bolt, so that it can be removed easily from its cage; and that the small washer used as a follower to the atomizer be screwed into the cage, and made longer, so that the excessive pressure of the injection of air will not be against the packing and the studs. Also the crank cases should have large drainage faucets to facilitate cleaning.

The regulation of the Diesel engine is excellent, but my experience does not agree with the popular belief that any kind of fuel is "good enough." Usually crude oil will be found to hold too much water in suspension. A little water passing through the atomizer, while the engine is under a heavy load, will cause the speed to vary, although the governor takes care of this at once; yet without a voltage regulator on the switchboard, this variation of the speed would cause flickering of the lights. The distillate known as fuel oil, is often too thick, especially in the winter, as it will not run of its own accord. The arrangement of the suction valve on the governor will not seat itself, except by the aid of springs, and these do not act quickly enough with the heavy fuel oil to give good results.

Kerosene is good, but costs too much. This leaves us in this locality only with the fuel, known as "Solar oil." We have found this not only the best fuel to use in the Diesel engine, but the cheapest.

Our fuel bill, formerly $28 per day of 24 hr., has now fallen to $5 for the same period.

Great Bend, Kan. JOHN PIERCE.

REFRIGERATION DEPARTMENT

Ritz-Carlton Refrigerating Plant

One of New York City's newest and best equipped hotels is the Ritz-Carlton, on West Forty-sixth St. and Madison Ave. The building is 16 stories in height and contains 400 rooms. It is supplied with heat, light, power and refrigeration by a private plant in the basement 63 ft. below the street level. In a previous issue the heating and ventilating plant was described, and the present article will deal with the refrigerating apparatus. An addition has just been made to the plant for air cooling in the hot summer months and the compressor equipment now consists of three machines, two 50-ton compressors, and a 175-ton machine for the air cooling. All

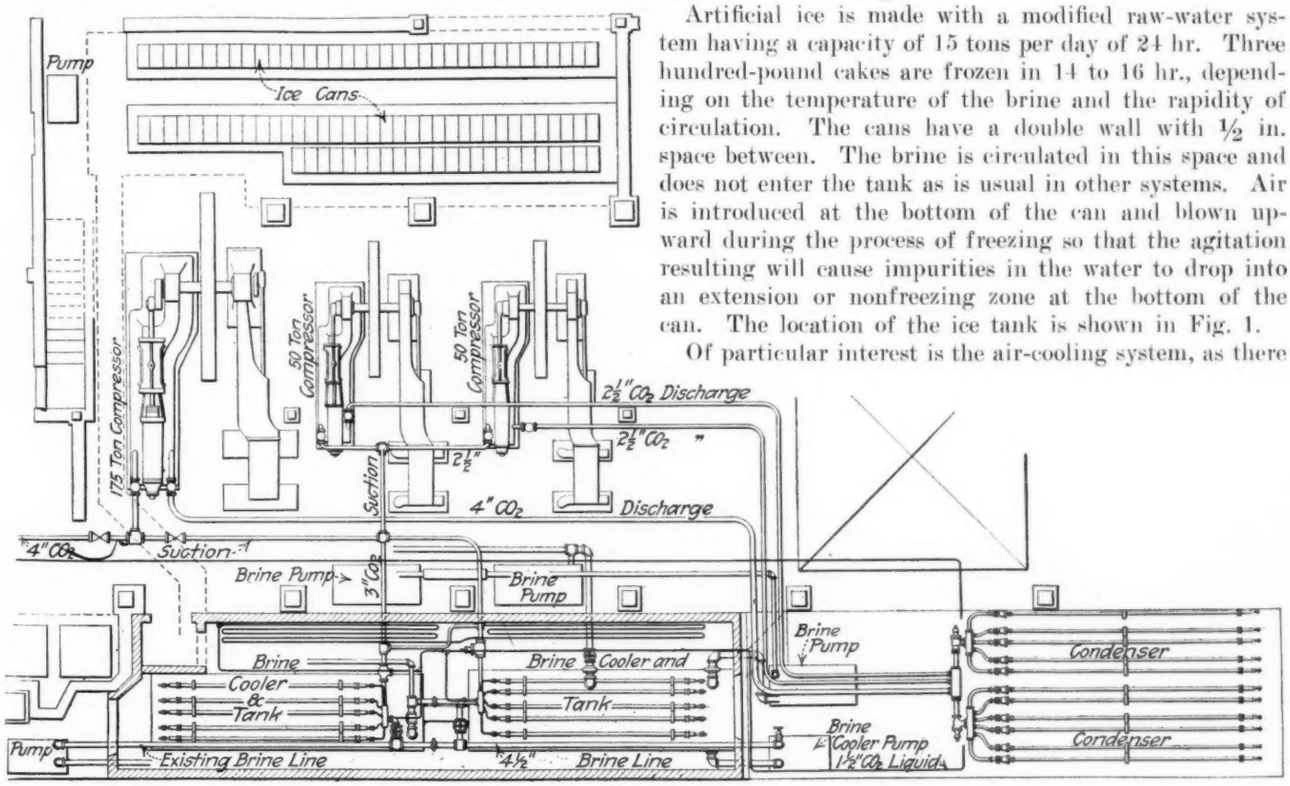


FIG. 1. ARRANGEMENT OF CO_2 PLANT IN THE RITZ-CARLTON

are Kroeschell carbon-dioxide compressors driven by simple Corliss engines; the smaller engines are 14x36 in. and the large engine 18x42 in. The machines work between a suction pressure of 20 atmospheres and a condenser pressure of 62 atmospheres. All are cross connected, so that any one compressor may be used for any service demanded of the refrigerating plant.

The condenser is of the double-pipe counter-current type, consisting of eleven sections of 1¼- and 2½-in. pipes 20 ft. long and 18 pipes high. During the winter months, cooling water of 39 deg. is available, and in the summer its temperature is around 76 deg. In close proximity to the condenser is the brine cooler, which is similar in type, size of pipe and length, and consists of 10 sections 12 pipes high. The general arrangement of the plant and size of the piping is shown in Fig. 1.

Primarily the plant was laid out for ice making and general refrigeration, consisting of a low-pressure brine line for cooling 96 refrigerators, a high-pressure brine system for cooling 14 service refrigerators from the third to the thirteenth floor, a water-cooling system on direct expansion with a capacity to cool 500 gal. of water per hour from 76 to 40 deg. F. and a caraffe freezer for the freezing of 500 water bottles for the tables. The temperature of the brine delivered to the refrigerators is +5 deg. F. and that for the ice-cream freezers ranges between 0 and —5 deg. F.

Artificial ice is made with a modified raw-water system having a capacity of 15 tons per day of 24 hr. Three hundred-pound cakes are frozen in 14 to 16 hr., depending on the temperature of the brine and the rapidity of circulation. The cans have a double wall with ½ in. space between. The brine is circulated in this space and does not enter the tank as is usual in other systems. Air is introduced at the bottom of the can and blown upward during the process of freezing so that the agitation resulting will cause impurities in the water to drop into an extension or nonfreezing zone at the bottom of the can. The location of the ice tank is shown in Fig. 1.

Of particular interest is the air-cooling system, as there are only a few installations of the kind in this country. The service is used for the ballroom, banquet hall and private dining rooms, and there is capacity to cool 60,000 cu.ft. of air 20 deg., with the temperature of the incoming air at 85 deg. F. and 60 per cent. humidity. The air to be cooled is conducted to an insulated room about 16 ft. wide, 12 ft. long and 7½ ft. high. Fig. 2 gives an indication of the layout. The same room is used for heating and tempering the air during the cold months and the same motor-driven fans circulate and distribute the air to the various rooms. As may be seen in the drawing, the air first passes over the tempering coils, which in the heating season are supplied with steam. It then

passes through a spray chamber where the impurities are washed out and comes in contact with coils of 1-in. direct-expansion piping, 75 ft. of pipe per ton of air cooling being allowed.

From spray nozzles at the top of the chamber a constant stream of water is kept flowing over the coils, which prevents the formation of frost and maintains the coils at their highest efficiency. The humidity is controlled by the drop in temperature through the coils. At the lower temperature the dew point is exceeded and part of the moisture is condensed. It is removed as the air passes through the eliminator at the outlet end of the chamber. In passing through the distributing ducts to the rooms the temperature of the air is raised by the

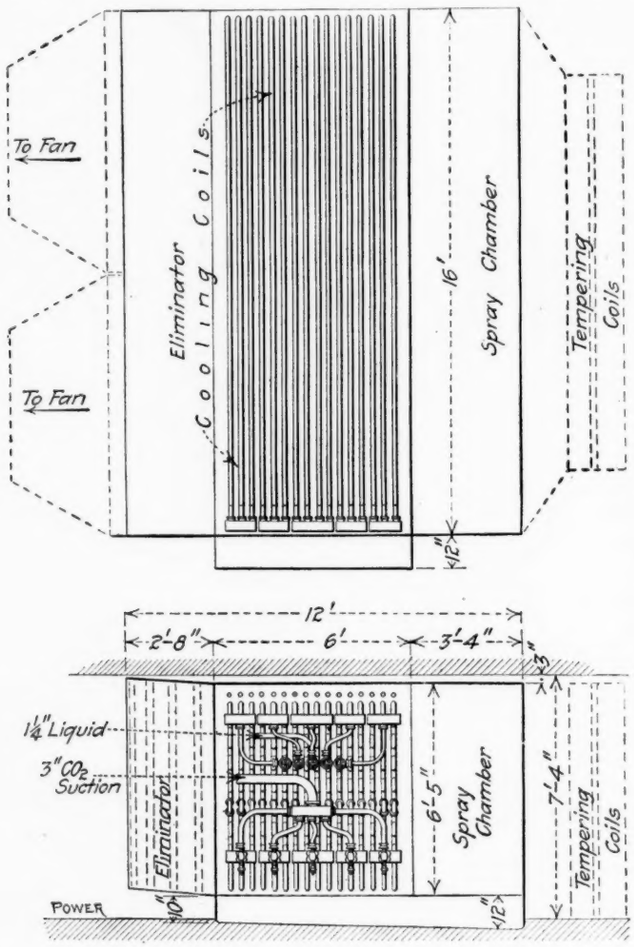


FIG. 2. AIR-COOLING CHAMBER

higher outside temperature. With the same amount of moisture the air will have a lower humidity at the higher temperature, so that by properly adjusting the drop and subsequent rise in temperature it is an easy matter to maintain the desired temperature and humidity in the rooms.

In each of the rooms to be cooled there is a series of registers at the ceiling and a second series at the floor. In the winter the air is introduced at the ceiling and drawn out at the floor, but in the summer months the circulation is reversed by means of reversing dampers in the ducts. The cold air enters at the floor and as it is heated rises to the outlets at the ceiling. For high rooms particularly this is the proper method, for if the air entered at the ceiling it would have lost most of its refrigerating effect before it reached the breathing line.

The system was laid out with capacity to change the air in the rooms every six minutes, but when the rooms are not fully occupied and the ventilating conditions are not severe at least half of the air can be recirculated and ventilation within the required limits still be maintained. For this purpose a recirculating duct has been provided. As the air drawn out of the rooms by the exhaust fan contains less moisture than outside air, less moisture has to be condensed in the cooling room and consequently less refrigeration is required. Regulation of the supply of cold air can be effected by a damper in the ducts or by the expansion valve at the entrance to the refrigerating coils.

The plant was erected under the supervision of John G. Lapham, Eastern manager of Kroeschell Brothers Ice Machine Co., of New York and Chicago, and to him we are responsible for much of the information contained in the article.

Watch Drain from Dehydrator

The dehydrator on an absorption machine is a very important part, and, yet, if not properly handled, it is a decided hindrance to the operation of the machine. Any irregularities in the operation of the dehydrator will bring about complicated conditions in the operation of the machine.

A combination angle and check valve is located in the drain pipe from the dehydrator to the generator. This valve is to prevent the gas from the generator taking a short cut through the dehydrator and also to let the drip from the dehydrator flow back to the generator. It is possible, when starting a machine, for the check in this valve to stick closed. This will let the dehydrator fill up with very rich aqua and overflow into the condenser; thence to the receiver and ice tanks. This condition robs the machine of aqua and gas, which is liable to cause "boiling over" and make the machine work badly. The temperature of this drain pipe should be closely watched by the operator.

G. A. ROBERTSON.

Louisville, Ky.

Congress of Refrigeration

The date for the Third International Congress of Refrigeration has been set for Sept. 17 to Oct. 1, 1913, inclusive. To carry out the exposition feature a separate organization, known as the International Refrigeration Exposition Association has been formed, and any information concerning space and other details may be obtained by addressing W. E. Skinner, general manager of the association, 819 Exchange Ave., Chicago. The International Amphitheater, 42nd and Halsted Sts., which has 75,000 sq.ft. of floor space has been secured, and as it is directly connected to 28 railway lines running into Chicago, there should be no difficulty in shipping exhibits. A great many of the engineering and manufacturers' associations will hold their annual or special meetings at the exposition, so that visitors may learn a great deal about the subject of refrigeration, as well as see its application in ice making, cold storage and other practical uses.

EDITORIALS

The Afflicted Middle West

Flood and flame in the Middle West, as has been noted in the daily press, have caused an appalling disaster. At this writing it is impossible to portray its horrors, nor do but scant justice to the always quick sympathy of the American people, who have opened their hearts and their purses with a readiness that makes us all proud of our country.

Galveston and San Francisco were local in their disasters when compared to this desolated region that is larger than some countries in Europe.

How heavily the disaster weighs upon the men in the operating field cannot now be learned. Their duty lies "below decks," and what sacrifices the engine and boiler-room forces have made may never come to light. It is theirs "to do and dare," and seldom does the public know of their heroism or their self-sacrifice.

To what extent the power plants, factories and office buildings in the afflicted cities have been wrecked or shut down is also unknown, but, however great the damage, there is some consolation in the knowledge that heat, light and power are among the first needs of this wasted territory and that the men in the operating field must of necessity soon be set at work.

This is a time when the engineer, trained to responsibility, will be leaned upon by those who would be wellnigh helpless without him. No one is better fitted to assume responsibility than he whose vocation daily, nay hourly, brings him face to face with danger; whose duty it is to protect the life and welfare of others, and whose calling has the prime requisites of skill, quick judgment and prompt action. Whatever public heed may be given to this engineer, he is absolutely necessary if public utilities are to perform their functions and comforts be provided.

⁂

A Remedy for Ill-Advised Legislation

Just now, when public complaint is so loud against the crowding of statute books with unnecessary and ill-advised laws, it is well that attention should be directed to one of the purposes of the technical societies and the useful work they are attempting.

As a case in point, it is announced by Charles Baskerville, chairman of the committee on occupational diseases in the chemical trades, appointed by the New York Section of the American Chemical Society, that the society stands ready to give the New York and New Jersey legislatures, and all manufacturers interested, the benefit of its services, and urges that they be utilized to the end that much unwise legislation and many commercial mistakes be prevented.

This is as it should be. No important step is taken by legislators and large industrial interests in most European countries without first seeking the approval of the society most fitted to pass upon the undertaking at issue.

In the United States there is an apparent inclination by legislative bodies and the industrial interests to ignore the societies. Why? It cannot be explained away by the assumption that our societies are not properly equipped to deal with any problem that may arise in their particular field of endeavor. These bodies are conspicuous both here and abroad for their good work, and in most cases are affiliated with the international organizations.

It is time that this matter be given the widest publicity, in order that the public may know that it has access to the services of the societies, and that they in turn gain the standing that should be theirs as sources of authority. It is not meant to give the impression that the public has a right to demand exhaustive investigations or ask purely consulting engineering involving personal sacrifice gratis, for "the laborer is worthy of his hire." These bodies can, and should be, however, consulted on all questions affecting the general welfare, both in the legislatures and in business.

When these conditions shall have been brought about we will have put a stop to much ignorant and pernicious legislation, prevented many costly business mistakes, and placed our societies on a plane where they will be much more useful and get public credit for that usefulness.

⁂

Poor Lighting in the Power Plant

Inadequate lighting in the power plant is the shallowest sort of false economy, yet many installations are very poorly illuminated. Any campaign for improved efficiency of operation which does not include a vigorous fight for first-class illumination misses an opportunity. There is no excuse for the failure to provide suitable lighting units now that the tungsten lamp with its efficiency of one and one-quarter watts per candlepower, even in the smaller sizes, is available.

Without proper light the provision of the best indicators, instruments and tools only partly meets the requirements of efficient operation. Even in a small plant electrical energy is cheap enough in these days to justify a liberal use of forty- or sixty-watt tungsten lamps above the machinery plane, and it is astounding how such an installation will improve conditions in a plant formerly lighted by ordinary sixteen-candlepower carbon incandescent lamps, whether singly or in small groups.

In most plants the machinery presents dark surfaces to the eye, and to facilitate inspection the volume of light must be relatively high. The use of white-enameled brickwork in the settings of boilers and of white marine or other durable paint on the walls in place of dark finishes are steps in the right direction. With the use of mechanical fuel-handling systems much of the dirt of the boiler room has been eliminated, but even the hand-fired establishment offers a good field for the use of special lighting. More care in providing suitable reflectors in front of gages and water columns, installing lamps so

that the light flux will be thrown upon bearings, gearing, starting boxes, fuse panels, scales and other auxiliary equipment, and in looking after regular cleaning of glassware will pay a high rate of interest on its cost.

A noteworthy improvement is that the firing aisles of some of the latest boiler rooms back up against large window spaces in the building walls, so that natural lighting and ventilation are secured with comparatively little trouble. Again, some of the best designing engineers are now preparing plans of station wiring in the same detail that pertain to the piping layouts, showing the size and location of every fixed lamp and switch in the establishment before the equipment goes into place. Detailed wiring diagrams of large buildings are long-established practice, but it is a new departure to devote an equal amount of care to power-house illumination plans.

To treat this important subject of station lighting from a fresh point of view is difficult, but the recurrence of faulty practice in this field warrants renewed reference to its defects. It is a question if lighting by lamps connected in parallel even in electric-railway plants is not better practice than series illumination, since the multiple installation permits cutting out individual lighting units in out-of-the-way corners, when they are not required, better than the series installation.

All too often the effectiveness of the lighting is hampered by the insufficient protection of the fixtures against oil and carbon dust. A more thorough study of the best heights for lamps in relation to existing installations of machinery is needed in many plants, and the preparation of a lighting survey in a poorly illuminated power house with recommendations for better arranged and selected equipment is one of the most useful tasks which the engineer can undertake if he is prepared to present his facts and conclusions to his superior with tact and sound judgment. Fortunately, many of these improvements can be had at extremely low cost.

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Practical Studies of Depreciation

The accumulation of accurate data bearing upon power-plant depreciation is well worth the attention of operating engineers. There is scarcely another subject in which educated guesswork plays so large a part. Actual life records of individual equipment are literally worth their weight in gold at times when the owner of a plant wishes to sell it or raise money upon its performance and status, as when an electric-lighting or street-railway company appears before a state commission to obtain authority to float a bond or a stock issue. While such work may seem none of his concern, it is a fact that the operating engineer can often help his employer prepare a better case if he has made it a practice to keep life and depreciation data. It is not a work which will yield immediate results, but it is one which should be carried on as a sort of side line when the opportunity is favorable.

Judging from the way in which data are presented before public-utility commissions by power and lighting companies, here is a field where the operating engineer can make himself more useful if he is of a methodical mental turn. More and more these commissions are calling for specific data as to the life of all kinds of machinery, the amounts which must be expended upon it for repairs and the wear and tear which finally make it necessary to replace it with new equipment. Too often only approximate guesses are offered as to the life of apparatus, based upon the general opinions of executives more or less out of touch with the details of replacement and the multitude of little costs which amount to such surprising totals in the course of a few years. As a result the commission discounts the company's statements and exhibits, unless they can in a measure be checked, or else it accepts the estimate of the company and perhaps, through the latter's own inadequate notions as to its depreciation costs, does not authorize sufficient money to enable the property to be carried on in the best possible way financially, simply because the petitioner for the right to issue funded paper did not realize the extent of its depreciation. Even if an overestimate is presented, there may be an economic injustice perpetrated; but where data are submitted based on actual costs and life records, it would seem that a fairer solution of the problem might be attained.

To go about such a task the engineer should put down in a notebook the date of installation of every important piece of machinery in the plant, its first cost, where he can obtain it, and the dates and costs of all replacements and repairs in the nature of renewals affecting each machine unit under his charge. This is simple to do if it is begun at the right time and kept up as long as the plant keeps going. It may be necessary for the engineer to pass the maintenance and depreciation record book along to his successor; in fact, it is not likely that such a record will begin to have much real value until perhaps five or ten years after the plant is placed in operation, but the older it gets, the more useful it will become.

If such a practice as this were widely carried on, with the appreciative coöperation of engineers in charge of plants and their superiors, the whole industry would be enriched in a comparatively few years along lines which are at present largely subject to the roughest estimates, and to "blanket" allowances for depreciation which cannot be audited or checked as could specific figures taken from actual practice in the installation of new parts and the renewal of machines. Doubtless information of this kind is supposed to exist in many well managed companies, but as a matter of fact it is exceedingly scarce. There is room for pioneer work of a genuinely scientific character to be done in this important field by engineers who are ambitious to become something more than creatures of routine.

The extension of the principles and practices of commission regulation over the affairs of public-service companies is bringing out new phases of their costs almost every week, and the thoroughness with which evidence is prepared often means more to such companies at the hands of the regulating tribunal than the gains of many months in unit cost of production at the generating station or in improvements in the economy of transmission. Engineering work lies at the very foundation of just and efficient administration of such utilities, and the far-sighted operating engineer should realize this, even if there appears to be no present demand for his services in this apparently exalted field.

❖

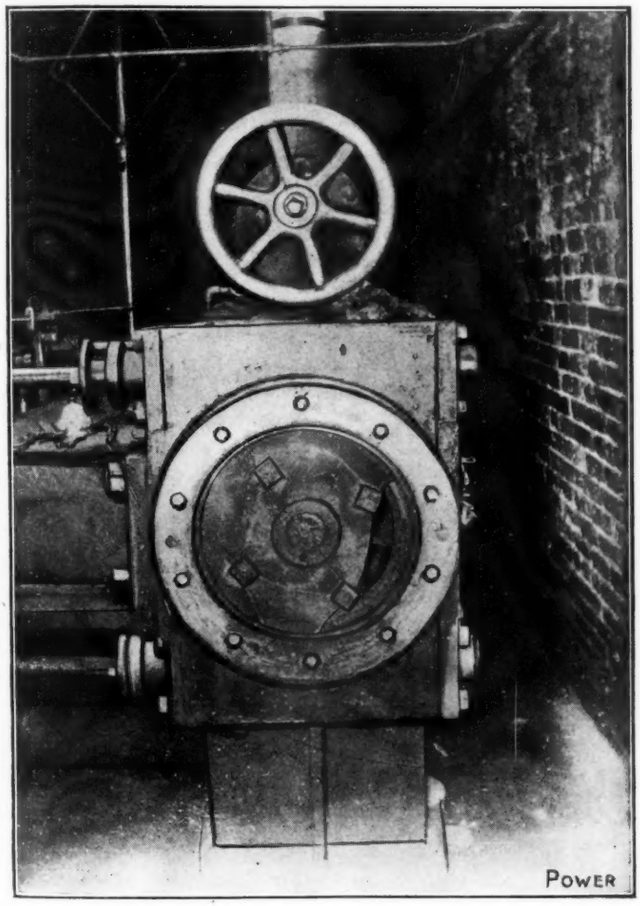
Those who have been following the study course will have a chance to test themselves with this week's review and rest. Next week the answers will be given and the week following the course on combustion will start.

READERS WITH SOMETHING TO SAY

Piston Rod Pulled out of Crosshead

On Wednesday, Jan. 15, an accident to the 16x48-in. engine at the J. C. Bennett estate, in West Lynn, Mass., shut the plant down until connections could be made with the local central station and motors installed to run the plant. The engine was built by Corliss & Nightingale in 1848, and its career is probably ended as repairs are not contemplated. The engine ran at 70 r.p.m. with a boiler pressure of 100 lb.

The direct cause of the accident was the separation of the piston rod from the crosshead, due to the threads



FRACTURED PISTON HEAD

on the end of the rod and in the crosshead having worn from looseness and long continued play until the holding power of the threads was unequal to the strain to which they were subjected; the pull of the piston-rod nut at each taking up of the slack no doubt hastened the final separation.

A short time previous to the accident the engineer noticed play between the rod nut and crosshead. The engine was stopped and the nut drawn up tight against the crosshead, after which the engine was again started and brought up to speed. The engineer had barely completed opening the throttle and stepped to one side to note the effect of tightening the nut when the piston crashed into the cylinder head, shearing the studs, breaking the head into four pieces, and otherwise damaging the engine.

The illustration shows the piston in the position it was found after the accident, the broken follower plate, and also the position directly in front of the cylinder head which the operator was obliged to assume while manipulating the throttle. Remarks concerning the engineer's narrow escape from death or serious injury seem superfluous.

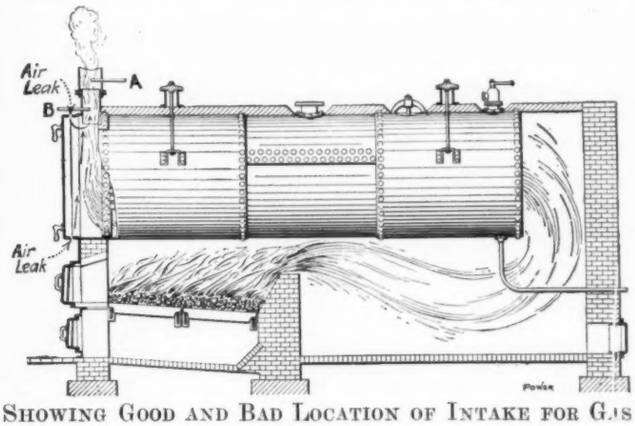
CHARLES F. ADAMS.

Lynn, Mass.

Taking Flue Gas Samples

In the analysis of flue gases as in everything else there is a right and wrong way to do it. The object of analyzing flue gases is usually to study combustion conditions and if the method of collecting the gas is correct and the analyses are properly made there can be no better way of determining these conditions.

Much depends on where the sample of gas is taken,



SHOWING GOOD AND BAD LOCATION OF INTAKE FOR GAS SAMPLING

and the object of the analysis. If, for instance, the object is to keep close "tabs" on combustion conditions, as in running an efficiency test, gas analyses should be made every few minutes, particularly if burning bituminous coal. If, however, the object is to check up the general average of a boiler, plant or fireman, some good method of drawing out an average sample covering the entire watch and an analysis of one sample at the end of the watch would be sufficient, or a reliable CO_2 recorder could be used.

Recently I assisted in testing a horizontal return-tubular boiler burning bituminous coal. The test was on when I reached the boiler room. The gas was being drawn from the breeching at about the point *A* in the illustration. I had a hole drilled in the furnace front just above the front doors. These doors were like those

in most settings of this sort in that they did not close tightly, and, therefore, leaked much air, which, mixed with the gases, diluted them, and showed a comparatively low per cent. of CO_2. When the sample was taken out of the tube marked *B* in the illustration, the CO_2 was higher than when taken from the point *A*. Samples drawn from *A* analyzed about 8 per cent.; samples drawn from *B* about 14 per cent.

The object of this test was to determine the efficiency of a patented furnace, and much depended upon keeping the fire in good condition. As there is a definite relation between the percentage of CO_2 and the holes in the fire, I believe it is important to take samples every few minutes and analyze them right at the boiler, for the reason that changes in conditions occur rapidly. Once in this test a sample of gas showed 4 per cent. CO_2. We got the fireman to break up his fire, level it off, and a sample of the gas then taken showed 14 per cent. Between these two readings about three minutes elapsed. By the method used by the chemist on this job little would have been learned, for it took him five minutes to walk to the laboratory, and another ten minutes to analyze the sample, so that the shortest intervals between analyses would have been twenty minutes. In the meantime many changes might have taken place in the furnace.

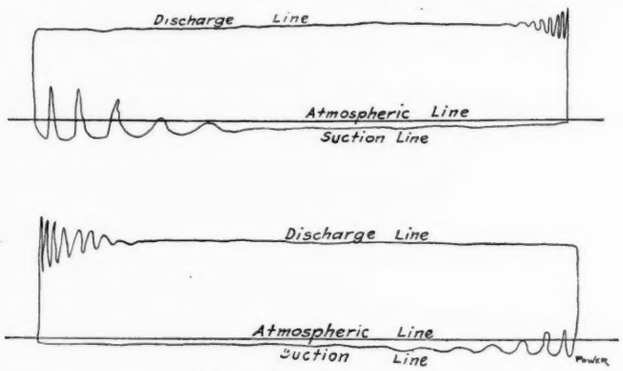
ALFRED FRANKLIN.

Cheltenham, Penn.

What Causes the Wavy Suction Lines?

The accompanying diagrams were taken from a double-acting, duplex pump of 5,000,000 gal. daily capacity, with a suction lift of approximately 10 ft., running at 30 r.p.m. and having a 30-in. stroke.

I would like to hear from some experienced pump man



WAVY SUCTION LINES

as to the causes of the wavy suction lines on the indicator diagrams.

J. F. REYNOLDS.

Phoenix, Ariz.

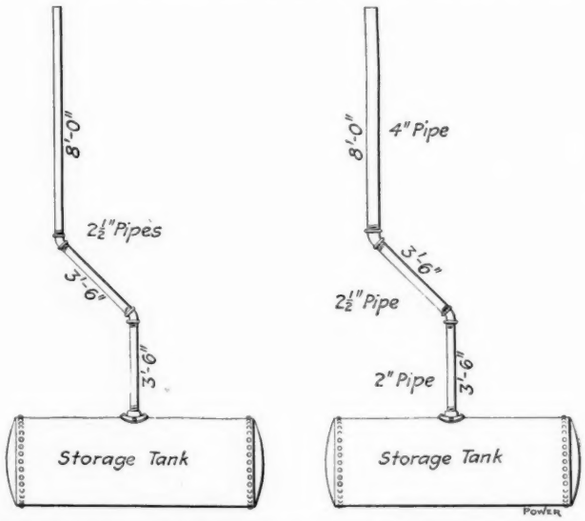
Oil Flow Problem for Discussion

Recently my attention was called to a plant using fuel oil in its furnaces. A storage tank was placed 15 ft. below the surface of the street, and had a 2½-in. pipe fitted as shown in Fig. 1.

The tank's supply of 1100 gal. was received from a common oil-delivery wagon through this 2½-in. pipe. A solid connection was made between the delivery wagon and the top of this pipe thereby providing all the head attainable, and then it took 45 min. for the 1100 gal. to flow into the storage tank.

The oil company demanded the reconstruction of the delivery pipe, and by reason of different obstructions, a straight pipe could not be used. As a result, the 8-ft. length of 2½-in. pipe was removed and one of the same length, 4 in. in diameter, fitted in its place, as shown in Fig. 2; the remaining 7 ft. of pipe was undisturbed.

With this arrangement, the oil was simply permitted



GOOD AND BAD CONNECTIONS TO OIL-STORAGE TANKS

to flow out of the delivery wagon into the top end of this 4-in. pipe. The oil in the wagon providing no head for the pipe connected with the storage tank, as no connection between it and the delivery wagon had been prepared, and with this alteration, the 1100 gal. is discharged into the storage tank in 18 min.

The question is, how does this alteration produce the accelerated flow of oil?

H. O. MCCARTHY.

Vancouver, B. C.

Trouble with Piston Rod Packing

Considerable trouble has been had with the packing of the piston rod at the water end of our pump. This is because there is no suitable packing in the plant and I had to make the best of what could be found. In spite of all that could be done, a large stream of water would leak past the packing at each stroke, and, running on the floor, was very undesirable.

Recently I decided to make a packing out of material that could be found, and proceeded as follows: After thoroughly cleaning, the stuffing-box, some lamp wick was doubled and twisted until it was thick enough to fill the space between the piston rod and walls of the box, stuffing in as much as it would hold. Then the gland was put in place and the wicking pressed in around the rod, which left room enough to insert a few rings of ring packing. This arrangement has given satisfaction for the past six months on a pump that is used for pumping hot water.

JOHN KNAB, JR.

Maspeth, N. Y.

QUESTIONS BEFORE THE HOUSE

Corliss versus Four-Valve Engines

Concerning the respective merits of Corliss and nonreleasing gear four-valve engines, I believe that before considering any of B. E. Donovan's questions, as given in the Sept. 24 issue, it is appropriate to state that in spite of the better steam economy of well designed Corliss engines, there are other considerations which often make high-speed, four-valve engines more economical to install and operate.

A direct-connected unit with a Corliss engine occupies fully 60 per cent. more floor space than one with a high-speed engine. If high-priced land must be purchased with borrowed money and foundations and buildings erected with money likewise obtained, a heavy fixed charge is created, which in nearly every case is sufficient to more than offset the superior economy shown by Corliss engines and as these charges usually run for long periods, it is advisable to start them as low as possible.

This is why the high-speed four-valve engine is often guaranteed to equal the Corliss in economy, in many situations where real economy does not call for low steam consumption.

Many builders freely guarantee a water rate of 24 lb. per horsepower-hour, but a proposal from the buyer to penalize them for nonperformance and give bonus for any improvements usually causes them to raise the figure to 27 lb., which is the average for four-valve, high-speed engines under good service conditions.

It is not necessary to increase the clearance volume in four-valve engine cylinders as compared to the Corliss, of the same diameter, but the use of like volumes, with shorter strokes results in higher percentages of clearance in the high-speed engine. Thus a volume which is 3 per cent. of the piston displacement with a 40-in. stroke, will be 6 per cent. if the stroke is 20 in. and the bore the same.

It has been customary to regard all clearance as a source of waste, but the uniflow engines seem to contradict this view, as they are notable for large clearances and low steam consumption. This indicates that not the volume, but the area of the wall surface of the clearance is the more important factor in the source of loss.

Perhaps a good method of comparing engines as to probable steam consumption would be one based on the total internal surfaces of the cylinders to which the steam is exposed in a unit of time, making correction by means of the ratio of diagram factors. For instance, assume a Corliss engine with 20x40-in. cylinder at 112 r.p.m. using 23 lb. of water per i.hp.-hr.; and a four-valve, high-speed engine with 20x20-in. cylinder at 225 r.p.m. and unknown steam consumption. Assume that the cylinder has 7 sq.ft. of clearance wall area, including the cylinder head and piston.

The barrel of the 40-in. stroke cylinder has an area of 17.453 sq.ft. This plus 7 sq.ft. gives the Corliss engine a total surface per stroke of 24.453 sq.ft. The barrel of the 20-in. stroke cylinder has an area of 8.726 sq.ft. This plus 7 sq.ft. gives the four-valve engine a total surface per stroke, of 15.726 sq.ft. As the four-valve engine makes two strokes for one of the Corliss engine, we must double the figure 15.726, making 31.452 sq.ft.

We find then that the four-valve engine presents 31.452 sq.ft. of cooling surface to the steam in the same unit of time during which the Corliss presents 24.453 sq.ft., and were it not for the wire drawing and lower diagram factor of the four valves, the ratio

$$\frac{31.452}{24.453} = 1.286$$

would be an index of the relative water consumption of the engines.

The lower diagram factor makes necessary a longer cutoff in the high-speed than in the Corliss engine to do equal work. This gives a higher terminal pressure and temperature in the four-valve engine and with the wire drawing tends to produce a more even range of temperature in the cylinder of the high-speed engine.

Assuming that the gain due to the reduction of the diagram factor is proportional to the reduction and using Mr. Donovan's figures 0.87 and 0.95 we get $\frac{0.87}{0.95} = 0.915$ as the correction factor, and the steam used by the four-valve engine will be

$$23 \times \frac{31.452}{24.453} \times \frac{0.87}{0.95} = 27 + \textit{lb. per i.hp.-hr.}$$

This is an average figure for high-speed four-valve engines, in which high compression is used. It is to be noted that those using low compression are more economical but usually do not regulate well. It is not possible to make a showing of low-steam consumption, and still not do it, but it is often possible to make a good showing of commercial economy with relatively high-steam consumption.

The movements of the valves in both types are due to the load carried. The main differences are that the Corliss valves open more fully and close more rapidly than those actuated by nonreleasing gears.

The short connecting-rods of high-speed engines should not materially affect the mean effective pressure of the indicator diagram but they do produce fluctuations of crank effort, which are equalized by the flywheel if it is sufficiently heavy.

Wear in four-valve high-speed engines is more rapid than in Corliss engines, particularly in the valves, if of the Corliss type. A true Corliss valve is relatively very narrow, when compared with the bore of the valve chamber; hence its tendency to roll is not so great as is that of valves the faces of which embrace nearly half the circumference of the valve chamber. Such a valve even if only slightly worn will roll away from one of its ports, permitting leakage, while the true Corliss valve, being narrow, seats firmly over its single port practically sealing it. This is no doubt the reason why four-valve high-speed engines fall off in economy after comparative-

ly short periods of operation. For this reason those with flat admission valves are probably preferable to those with four semi-rotary valves.

The nonreleasing gear will wear rapidly if its bearings and pins are soft, as the alternately acute and obtuse angles assumed by the valve rods combined with inertia effects produce heavy stresses in the gear. The governor must be very stable, or the wear on its pins and bearings will be rapid and good regulation will not be maintained.

With high-speed four-valve engines it is hardly possible to make good on a guaranteed steam economy as good as the economy of Corliss engines if cylinder diameters and characteristics of design, aside from the valve-operating mechanism, are alike.

None of the foregoing should be taken as condemnatory to the four-valve high-speed engine, as it has a peculiar field of usefulness, which no Corliss engine can fill equally well.

CHARLES F. PRESCOTT.

Los Angeles, Calif.

In answer to B. E. Donovan's inquiry, I would say that one reason that the nonreleasing four-valve engine shows economies quite equal to the releasing or Corliss type is that the time interval between the incoming and outgoing steam is more rapid and does not effect as great a variation in temperature on the cylinder walls, piston and rod; also less condensation occurs, due to this cause.

There is no practical reason why the clearance space should be increased just because the piston nears the cylinder head a greater number of times per minute.

The valve-gears of Corliss engines have been improved to admit of noiseless operation at higher speeds and the frames built are more rigid to admit of higher speeds and greater steam pressures. High-speed governors give closer regulation, etc.

If an engine is run entirely without compression the space due to clearance would be filled from the exhaust to the steam-line pressure with live steam and this is a waste.

It does not require as large a cylinder in the higher speed nonreleasing type to get the same piston travel per minute or to get the same number of foot-pounds of work done per minute.

The makers of the nonreleasing type cannot make their guarantee unless they can back it up; besides the round corner at cutoff on the indicator diagram is about offset by the late release on the single-eccentric Corliss. Some nonreleasing-type engines run in an inclosed crank case with a splash-oiling system and some of them have a valve-gear partially submerged in oil and the gear is not under the strain of lifting the dashpots, which is quite severe on single-eccentric Corliss engines running at high speeds.

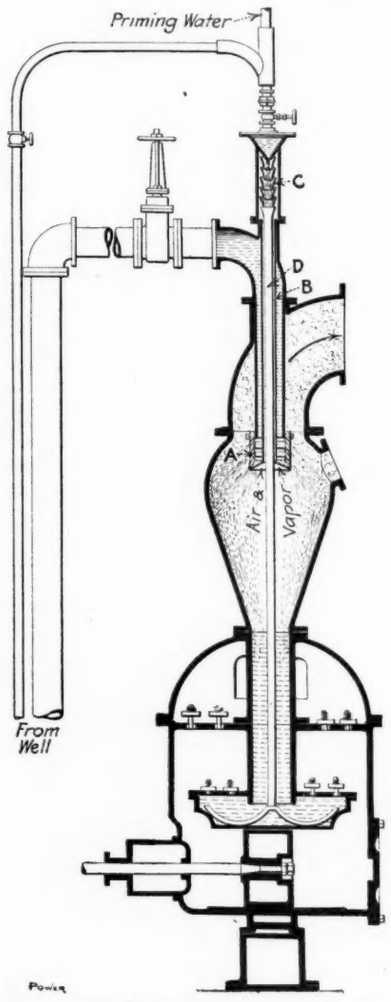
With no compensating adjustment in the cam levers the cutoff becomes increasingly later on the head end up to the half stroke as compared with the crank end, also the slower movement of the piston coupled with a slightly quicker opening of the steam valve has a tendency to hold the steam line up better on the crank end of the single-eccentric type Corliss engine.

Possibly the connecting-rod appears to be short on the nonreleasing type and yet, if compared with the length of its stroke, it would not in reality be so different. Many high-speed Corliss engines have a connecting-rod only two and a half times the length of the stroke.

Emmetsburg, Iowa. LEROY H. WHEAT.

Independent Air Pump for Condensers

In the Jan. 28 issue there appear extracts from a paper by William Weir, in which are described several European forms of pumps and nozzles for the separate extraction of air from condensers. In Fig. 1, page 134,



AIR REMOVED BY SMALL BAROMETRIC CONDENSER

is shown a "Dual" air pump, concerning which is said, "The wet pump *A* is situated below the steam cylinder, as this pump is the one which works under the maximum load. The dry pump *B* is driven by the beam and links in the usual way."

As, presumably, each plunger is single acting, is not the action of the pump as a whole very erratic? I would infer that the wet-pump plunger would plunge indeed when descending, and, judging from American practice, would soon bump and rattle itself to pieces unless steadied by a flywheel.

And will not the vacuum fluctuate considerably within the condenser as the result of the intermittent action of this slow-speed, single-acting, dry-air pump? I have often been told that the efficiency of an air pump de-

pends, in a large measure, on its ability to maintain a constant flow of air from the condenser, and for this reason, among others, a comparatively small double-acting pump, running at a fair speed, is to be preferred for a condenser auxiliary.

It will be observed that the dry-air pump discharges into the wet-air pump "at a point below the head valve." What advantage is derived from this novel arrangement? Is a partial vacuum formed in this space on the downstroke of the bucket? Is the dry-air pump caused to discharge here to take advantage of it? I can see no other reason than a worthy attempt to overcome atmospheric pressure by dual compression, obtaining a two-stage effect.

But, assume an efficient air pump and one of proper size. When the plunger ascends, the condensate follows it, and, when at the end of its upward stroke, water should be touching both its top and bottom surfaces. How shall a vacuum be formed, especially if it is considered that the top sheet of water is subject to atmospheric pressure? If a vacuum is formed, might not the gaging of the amount be a reliable indication of the efficiency (or inefficiency) of the wet-air pump?

I am not in a position to test this; although we have a 14 and 32 by 21-in. "twin" as the auxiliary of a 1500-hp. engine. In this pump the head valve deck has been removed—in fact, it never was installed. For ten years the pump has given excellent service.

Are head valves a benefit to upright pumps; do they not retard the liberation of the air entrained in the water and make it necessary for the plunger to deal with this elusive element once more than is needed?

While on this subject, it may be pertinent to mention my own experience. Three years ago I helped a brother devise means for extracting air from a jet condenser. The main details are shown diagrammatically in the sketch.

It will be observed that the novel feature is the incorporation of a small barometric condenser as an auxiliary for the separate cooling and eliminating of the air. In the sketch, *A* is the cone distributor, which is secured by setscrews to the internal injection pipe and which closely hugs the air pipe *B*. The air collecting under the cone ascends pipe *B* and enters the chamber *C*, from which it is forcibly ejected by the descending jet of water and delivered, through the pipe *D*, in the form of cool aërated water into the suction chamber.

By increasing the mean effective pressure by one pound on the low-pressure piston, this improvement effects a saving of about $500 per year, with but a negligible loss in feed-water temperature at the primary heater, as a large economizer is in service.

R. O. Richards.

Framingham, Mass.

Indicator Diagrams from High Duty Pumping Engine

It seems surprising after Mr. Tucker's able comments on his own diagrams, page 348 of Power, that he should not be acquainted with a fundamental phenomenon of cross-compound engines.

During the first half of the high-pressure piston stroke, steam is exhausting into the receiver, without the existence of any outlet from it, unavoidably resulting in an increase of back pressure upon the high-pressure cylinder. But when the high-pressure piston is at mid stroke, admission to the low-pressure cylinder from the receiver occurs, creating an outlet from the receiver and thus decreasing the back pressure upon the high-pressure cylinder. The inevitable effect of these events upon a diagram taken from the high-pressure cylinder, is to produce the slight "hump" in the back-pressure line, which so concerns Mr. Tucker.

Lloyd W. Taylor.

Grinnell, Iowa.

Names for "Steam Stuff"

In the editorial columns, Mar. 11, I note the call for suggestions on a new word for "steam stuff." Why not call it "hydrol"? That is the new chemical name for water in its various forms. Steam is mono-hydrol, H_2O. Boiling water is (supposed to be) di-hydrol, $(H_2O)_2$. Cold water is a mixture of perhaps di,- tri- and tetra-hydrols, thus $(H_2O)_2$, $(H_2O)_3$, $(H_2O)_4$. Ice is a further polymer $[(H_2O)_n]x$.

Charles S. Palmer.

Newtonville, Mass.

A SUGGESTION

Oh, Power is in a great sweat,
Steam stuff, to rename, when it's wet,
The editor's stumped
Suggestions have slumped
"Hy-drox" may prove the best yet.

John Bailey.

Milwaukee, Wis.

Remedy for Lubricator Trouble

Referring to Mr. Rush's letter about a faulty lubricator, in Power, Feb. 18, I think the trouble is in the long and indirect connection between the sight-feed and main steam pipe. If Mr. Rush will connect the lubricator into the side of the steam pipe, doing away with the elbow, and at the same time bring the sight-feed as near to the pipe as possible, I think he will have no further trouble.

G. E. Madeley.

Brownsville, Tex.

If Mr. Rush will connect the nipple of the oil-delivery line from the lubricator to the side of the steam pipe, he will have no trouble with oil backing up in the glass.

He should be sure that the vertical 1-in. pipe on the side is at least 4 ft. higher than the oil well.

L. G. Borden.

Wharton, Tex.

If Mr. Rush will raise the lubricator so that the oil outlet will be on a level with or slightly above the steam main, the lubricator will work. At present there is no chance for a supply of water to reach the glass once the pipe outlet fills with oil.

James Noble.

Toronto, Ont., Canada.

INQUIRIES OF GENERAL INTEREST

Connecting-Rod Angularity and Compression—How does the angularity of the connecting-rod affect the compression?

K. S. V.

The angularity of the connecting-rod has the effect of making the compression less on the crank end than on the head end because the crank-end compression occurs during a relatively smaller part of the stroke than the head-end compression.

Unequal Generator Voltages—When two alternating-current generators are connected to the same busbars and each carries 2000 kw. and uses the same amount of field current, what could account for unequal voltages on the two machines? (One is 6600 and the other 6400 volts.)

H. J. B.

Apparently the difference in voltage is due to the two machines not having the same excitation characteristics.

Earlier Cutoff—How can the cutoff be made earlier in a plain slide-valve engine without altering the port opening?

V. K. S.

Advancing the eccentric on the shaft would probably be the best way to make the cutoff earlier. If this is not feasible it may be possible to accomplish the desired result by adding lap to the steam ends of the valve or increasing the throw of the eccentric.

Fusible Plugs—What is the difference between an inside and an outside fusible plug?

S. C.

Fusible plugs for boilers may be entered in the tubes or shell of a boiler from either the fire side or the pressure side, or may be entered in the shells of the drums of a water-tube boiler in the same two ways. When entered from the pressure side they are called "inside fusible plugs" and when entered from the fire side "outside fusible plugs."

Position of Eccentric with Reversing Rocker—If a reversing rocker is used on an ordinary slide-valve engine will the eccentric occupy the same position as with a direct rocker?

S. K. V.

If a reversing rocker is used, the eccentric will not occupy the same position on the shaft as with a direct rocker, for with the latter the eccentric will be 90 deg. plus the angle of advance ahead of the crank while with a reversing rocker it will be 90 deg. less the angle of advance behind the crank.

Making a Barometer—In making a barometer, how can all the air be removed from the tube so as to get a correct reading?

F. P. B.

The mercury must be thoroughly boiled to expel air or other gases. After filling the barometer tube the mercury should be boiled in the tube to expel air bubbles that may adhere to the surface of the glass. For boiling out the air, the filled tube, open end up, can be heated directly by an alcohol lamp or the tube can be placed vertically in a bath of warm oil.

Deposit On Positive Wire—What is the cause of a deposit on the positive mains of an electric distribution system (light and power) in mines?

P. M. C.

Mine atmosphere contains sulphuric acid and often nitric as well. These two combining form aqua regia, a very powerful acid which attacks copper and forms a coating of oxide. It would seem that the deposit should be on the negative rather than the positive if electrolytic action has any part in it.

[If anyone can suggest an explanation for the reverse being true we should like to hear from them.—Editor].

"Double-eccentric" Corliss Engine—What is a "double-eccentric" on a Corliss engine? What is it for and how is it set?

E. P.

Strictly speaking, there is no such thing as a "double eccentric" on a Corliss engine. The name is frequently used to signify the presence of two eccentrics, i.e., one for the steam and one for the exhaust valves. Separate eccentrics are used to secure independent action of the steam and exhaust valves. The eccentrics are set at approximately 90 deg. with the crank, depending on the design and proportions of the valve-gear.

Pump Discharge Exceeding Piston Displacement—Can the amount of water actually delivered by a pump against a head exceed the piston displacement?

C. P. J.

This might be possible under certain conditions. When the rate of displacement by the piston is reduced without corresponding reduction in the velocity of the water through the suction pipe, the momentum of the water may be so great that, acting like a hydraulic ram, the velocity set up may be great enough to create sufficient pressure for some of the water to be delivered through the discharge valves. Any quantity thus discharged would be in excess of the actual piston displacement.

Edison Storage Battery—What are the materials used in the Edison storage battery?

A. B. D.

The positive element is nickel hydrate and the negative iron oxide. The electrolyte is a 21 per cent. solution of caustic potash containing a small amount of lithium hydrate. The nickel hydrate is loaded into perforated steel tubes in thin layers (about 300 layers per tube) and between each two layers is a thin layer of pure nickel to improve the electrical contact. The same function is served with the iron element by mixing with it, before loading, a little mercury oxide. The tubes are held by steel threads and the positive and negative elements are insulated from one another by rubber pins.

Fuel Oil—How many pounds of water will a pound of average fuel oil evaporate when fired under a large water-tube boiler? What is the weight of a cubic foot of fuel oil?

S. K. B.

California oil burned under water-tube boilers has been reported to evaporate the equivalent of 14.314 to 14.839 lb. of water from and at 212 deg. F. per pound of oil.

California, Texas and Java fuel oils have a specific gravity of about 0.92, while some oils from the eastern United States have a specific gravity of 0.84 to 0.87. The weight of a cubic foot of water (at 62 deg. F.) being 62.355 lb., the weight per cubic foot of any oil is found by multiplying 62.355 by its specific gravity. For example, California oil, or any other oil of 0.92 specific gravity, weighs

$$62.355 \times 0.92 = 57.36 \text{ lb. per cu.ft.}$$

Question of Boiler Capacity—Will a capacity of 520 hp. in water-tube boilers be sufficient to supply a vertical compound marine-type engine in a 400-kw. generating set?

G. F. B.

A boiler horsepower is usually based on an evaporation of 34½ lb. of water from and at 212 deg. F. (equivalent evaporation). This under the ordinary actual pressure corresponds to 30 lb. of water per hour, so the steam available from the boilers at normal rating would be

$$520 \times 30 = 15{,}600 \text{ lb.}$$

A compound condensing engine would use 20 to 22 lb. of steam per horsepower-hour, so that the boiler could supply an engine of this kind as large as

$$\frac{15{,}600}{22} = 709.09 \text{ hp.}$$

A compound noncondensing engine should not take over 26 lb. of steam per horsepower-hour, and therefore might be as large as

$$\frac{15{,}600}{26} = 600 \text{ hp.}$$

and not overtax the boiler.

As 400 kw. is equal to

$$\frac{400 \times 1000}{746} = 536 \text{ hp.}$$

the boiler capacity is ample even if the engine is to be operated noncondensing.

ENGINEERS' STUDY COURSE

Review of Mathematics with Test Questions

In this issue we conclude the lessons in mathematics by a review of previous lessons. In the lessons that follow, problems will be met with that require the use of mathematics, so the student is sure to receive plenty of practice in the subject.

To assist him in answering the following questions, the student is urged to make a brief review of all previous lessons. Answers to these questions will be given in next week's issue.

Following the review of mathematics will come several lessons in combustion and flue-gas analysis. After this, other subjects of importance to the engineer will be taken up.

(1) In the expression $\frac{1680}{144}$, which is the numerator and which the denominator?

(2) Express $\frac{22{,}043}{32}$ as a mixed number.

(3) Perform the following example by cancelation:

$$\frac{201 \times 740 \times 39 \times 16 \times 4}{8 \times 3 \times 4 \times 3 \times 37} =$$

(4) When addition and subtraction is indicated in an example, can the example be solved by cancelation?

The *least common denominator* of two or more fractions is the least number that will contain all the denominators of the fractions without a remainder.

To find the least common denominator, set all the denominators in a row and divide each that is so divisible by the smallest number (larger than 1) that will go into any of them without a remainder. Repeat the process until there are no remainders. Whenever a number or a remainder will not divide by the divisor then taken, bring the number down without dividing. Now multiply together all the divisors; the product will be the least common denominator.

Example: Find the least common denominator of $\frac{7}{18}$, $\frac{6}{9}$, $\frac{8}{12}$.

$$\begin{array}{r|l} 2 & 18 - 12 - 9 \\ 2 & 9 - 6 - 9 \\ 3 & 9 - 3 - 9 \\ 3 & 3 - 1 - 3 \\ \hline & 1 - 1 - 1 \end{array}$$

$2 \times 2 \times 3 \times 3 = 32 =$ least common denominator

When the value of the denominator is changed to that of the least common denominator, the value of the numerator must be correspondingly changed so that the value of the given fraction will not be changed.

Thus the least common denominator of $\frac{3}{4}$, $\frac{5}{8}$, $\frac{5}{16}$ is 16, but when the denominator 16 is used we must change the numerators as $\frac{3}{4} = \frac{12}{16}$; $\frac{5}{8} = \frac{10}{16}$; $\frac{5}{16} = \frac{5}{16}$.

Notice that we multiply the numerator by the same number that we would multiply the denominator by to get the least common denominator.

(5) Find the sum of $44\frac{3}{32} + 51\frac{6}{64} + 202 + 75\frac{1}{4}$.

(6) Subtract $229\frac{7}{16}$ from $242\frac{4}{16}$.

(7) Subtract $18\frac{3}{32}$ from 19.

(8) What is the product of $19\frac{3}{4} \times 22\frac{5}{8}$?

(9) State the rule for division of fractions.

(10) What decimal part of a foot is 9 in.?

(11) How many liters in a gallon?

(12) What part of an inch is a millimeter?

(13) One B.t.u. equals 0.252 large calories or 252 small calories; what is the calorific value (large calories) of coal containing 13,500 B.t.u. per lb.?

(14) Has the volume of a barrel ever been definitely standardized?

(15) What is 212 deg. F. on the Centigrade scale?

(16) The listed price of a steam trap is $30 with "40 and 10 off," what is the actual price of the trap?

(17) How many pounds of combustible in a ton (2000 lb.) of coal containing 12 per cent. ash?

(18) The formulas for ratio are

$$Ratio = \frac{antecedent}{consequent}; \quad consequent = \frac{antecedent}{ratio};$$

$$antecedent = consequent \times ratio$$

What is the ratio of heating surface to grate surface in a boiler with a grate 7x9 ft. and with 950 sq.ft. of heating surface?

(19) What is the inverse ratio of 20:4?

(20) A pump discharging 220 gal. per min. fills a tank in 3 hr. How long will it take to fill the tank if it delivers 400 gal. per min.?

(21) What is the square of $224\frac{3}{4}$?

(22) What number multiplied once by itself will produce 789?

(23) A steel shaft is to run at 80 r.p.m., and is required to transmit 28 hp.; according to the D. K. Clark rule (see POWER, Jan. 7, 1913, page 32), what size shaft should be used?

(24) Solve by logarithms:

(a) 33x3;

(b) Find the log of 31,428;

(c) Of what number is 4.4980071 the log?

(d) Find the log of 31,444.73;

(e) Of what number is 4.4931343 the log?

(f) What is the value of 642^4?

In logarithmic tables, such as given in Kent's "Mechanical Engineers Pocket-Book," always use as the first two figures of the mantissa those given with the only complete mantissa (six places) contained in the same section of the table (boxed in with rules) that contains the last four figures of the mantissa. For example, take the log of 1413 (page 133, 7th edition; page 140, 8th edition). The mantissa will be 150142.

(25) To reduce the actual evaporation to an equivalent evaporation from and at 212 deg. F., the following formula is used:

$$W' = \frac{W\,(H - t + 32)}{970.4}$$

in which

W' = Equivalent evaporation from and at 212 deg.;
W = Actual evaporation;
H = Total heat of steam above 32 deg. F. at the pressure at which the water was evaporated;
t = Temperature of the feed water entering the boiler;
970.4 = Latent heat of evaporation.

To find the factor of evaporation use this formula

$$Factor = \left(\frac{H - t + 32}{970.4}\right)$$

In connection with these two formulas read the article "Factor of Evaporation," in the Mar. 11 issue, page 334.

Approximate the evaporation in your plant and apply the formulas for practice. Also turn back to page 276 of the Feb. 5 issue and work examples in safety-valve areas and commercial sizes by using the Massachusetts formula.

(26) How many degrees in ¾ of a circle?

Given the area of an equilateral triangle to find the length of a side.

An equilateral triangle being one, all of whose sides are equal, its altitude would divide the triangle into two right triangles.

Let
a = Altitude;
b = Base = Length of each side;
A = Area.

By the relations of the sides of a right triangle

$$b^2 = \left(\frac{b}{2}\right)^2 + a^2$$

or

$$a^2 = b^2 - \left(\frac{b}{2}\right)^2 = b^2 - \frac{b^2}{4} = \frac{4\,b^2 - b^2}{4} = \frac{3\,b^2}{4}$$

$$a = \sqrt{\frac{3\,b^2}{4}} = \sqrt{3}\left(\frac{b}{2}\right) = \frac{\sqrt{3}}{2} \times b$$

Since

$$\frac{\sqrt{3}}{2} = 0.866$$

$$a = 0.866\ b$$

But the area of any triangle is equal to half the product of the base by the altitude. Then the area of the equilateral triangle is

$$A = \tfrac{1}{2}\ (b \times a)$$

Substituting for a

$$A = \tfrac{1}{2}\ (b \times 0.866\ b) = \frac{0.866}{2}\ b^2 = 0.433\ b^2$$

then

$$b^2 = \frac{A}{0.433}$$

and

$$b = \sqrt{\frac{A}{0.433}}$$

which gives the formula for finding the side of an equilateral triangle when the area is given.

(27) What is the length of a side of an equilateral triangle having an area of 21.217 sq.in.?

(28) An inclined plane forms a triangle with the ground, the base measures 1762 ft., and the vertical distance between the ground and the elevated end of the plane is 662.5 ft. How long is the plane?

(29) If one gallon of paint will cover 42 sq.ft. of iron surface with three coats, how many gallons are necessary to paint a steel stack 60 ft. high, 6 ft. in diameter.

(30) What is meant by "mean circumference?"

(31) State the formula for finding the volume of a frustum of a pyramid or cone.

(32) Approximately, how many tons (2140 lb.) of pea coal will be contained in a bin $60\frac{5}{16}$ ft. long, $25\frac{7}{8}$ ft. high, and $31\frac{9}{16}$ ft. wide? One long ton (2240 lb.) of pea coal occupies 36.7 cu.ft.

(33) The solid cast-iron ball on a crane tackle chain is 11 in. in diameter. How much does it weigh, cast iron weighing 0.26 lb. per cu.in.?

ANSWERS TO PROBLEMS, MAR. 25 ISSUE

(1) $413.45.
(2) 1220.137 gal.

High-Speed Engine Wrecked

BY T. K. LEE

An accident to a 175-hp. high-speed engine at the electric-light plant, Benson, Minn., recently wrecked the engine. It was a compound, with 12 and 18 by 14-in. cylinder, of the center-crank type, directly connected to a 100-kw. generator and running at 240 r.p.m. at the time of the accident.

This unit was installed eight years ago and was used

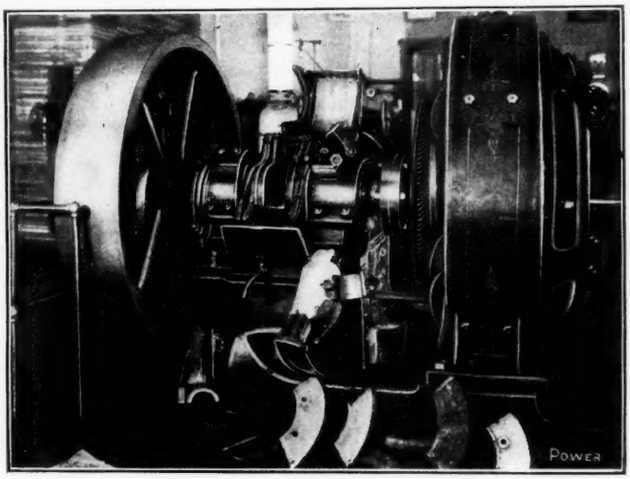


FIG. 1. CRANK END OF ENGINE

only for the peak evening load. Although the engine never gave any trouble, it was run only when the heavy load was on, because it was not economical in steam consumption. The engine had been running smoothly as ever, when the engineer, who had just come in from the boiler room, heard a sharp knock and the engine went to pieces.

The cylinder head and piston of the high-pressure cylinder was blown through the window, taking part of the wall with it and landed 50 ft. outside. The heavy counterweights on the crankshaft broke off and were thrown against the wall with great force, just missing the generator of the No. 2 unit.

The real cause of the accident was the breaking of one of the bolts holding the crank box together: a flaw was

plainly shown in this bolt. The other bolt held for some time, and was considerably bent before breaking.

When these bolts broke the connecting-rod dropped and the crankpin struck it with enough force to break it and send the piston against the head, shearing the studs and knocking out the cylinder head. In Fig. 1 is shown the crank end of the engine, the two counterweights which were broken and part of the broken connecting-rod. Fig.

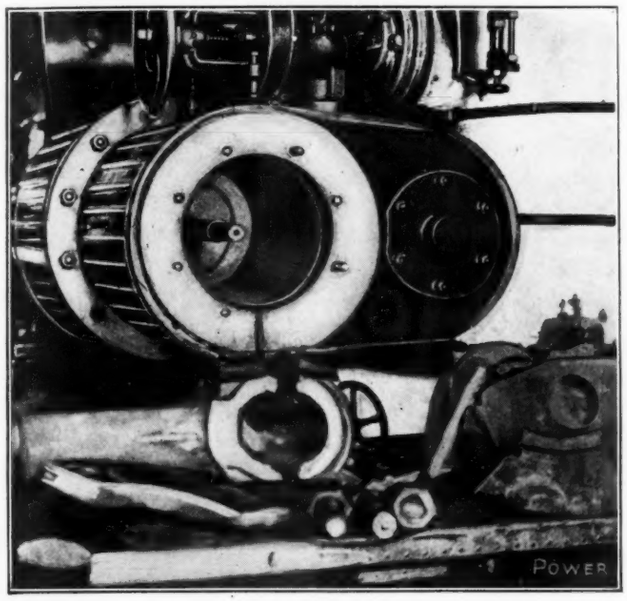


FIG. 2. HEAD END OF ENGINE

2 shows the head end of the engine with the head and piston knocked out. The stud bolts, 5/8 in. in diameter and spaced 5½ in. apart, were constructed of poor material.

Ocean Liner's Fuel Cost

The coal bill of a big trans-Atlantic liner is sufficiently great under ordinary circumstances, but when strike conditions prevail, with consequent high prices, the sum paid for sufficient fuel for a single voyage may amount almost to a small fortune.

The White Star liner "Olympic" for her last trip to this country was compelled to pay $5 per ton for her bunker coal, and had difficulty in securing enough to supply her needs at even this price. Her total expense for coal alone upon this voyage was $25,000.

Upon this trip the vessel carried 1586 passengers of all classes, and the expense for fuel for each passenger amounted in round numbers to $15.70. As the voyage was completed in 5 days, 18 hours and 46 min., the coal bill amounted to slightly over $3 per minute.

In reckoning fuel costs, all figures should be regarded as relative. Because one steamer burns a greater weight or value of coal than another, does not necessarily mean that her freight cost per ton-mile is any higher. It is probable that other vessels plying between the same ports at about the same time as the "Olympic" were compelled to pay equal rates per ton in order to fill their bunkers. It is doubtful, however, if any other steamer paid such an enormous sum for fuel enough for a single voyage.—*Coal Age.*

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

There is a scheme on foot up at Niagara Falls, N. Y., to develop hydro-electric power from the outflow of that city's trunk sewers. Phew! Why not let well enough alone? Just when things seem to be flowing smoothly, some gink always wants to stir things up. We don't favor the water-power "possibilities" in the average sewer.

A college professor has written a book entitled "English for Engineers" which its reviewer recommends "to engineers who desire a little strengthening of their English." We fail to see its need. Some of the strongest English we ever heard in our young life came from engineers. While the vocabulary may have had its limitations, the strength would never be questioned for a moment.

A careful study of old man Webster's tome of definitions would often convince bitter disputants that they really think alike.—"The Woodworker."

The trouble with the majority of these bitter disputants is that they too often agree with the man who would not buy a dictionary because every time he looked in it, the dum book was wrong!

My word! It must be jolly rippin', old top, to be grate maker to a king. Where the additional prestige comes in, we know not, but when the London "Electrical Review" makes this solemn proclamation, it must mean something:

"Makers to His Majesty—The Carron Co. has been appointed grate makers to H. M. the King. The Carron works have been visited on many occasions by Crown heads of Europe, including Czar Nicholas I of Russia, Prince Leopold Maximilian of Austria, and by King Edward VII, when Prince of Wales.

No longer should we wonder at the man in Holy Writ who sold his birthright for a mess of pottage, or at the individual who told us to stop his paper as he knew "as much as Power." Give ear to this:

> WILL EXCHANGE a one-hundred-dollar engineering course for a motor-cycle in good condition. Address R. P. M., Box 123, Boston, Mass.

If "the pen is mightier than the sword," the pen has committed hari-kari in a mighty funny item in a Boston daily. It says that "the superheated locomotive is so called because the water in the tank is heated in order that it may be all ready to steam when it goes into the boiler." Well, I'll be gormed!

"THE EVIL OF POWER"

A reader in New Hampshire sent us this sketch, and said it was a joke we married men will appreciate. We do. We

are glad to state that our Lovey is not this kind of a lady but pained to learn that POWER has ever busted apart an apparently once loving couple. Have a care, Hen Jones; "hell hath no fury like a woman scorned!" You win Lovey's trusting, tender heart, and then you neglect her for a literary career (There's lots more we might say about Lovey, but we're afraid we'd rouse your jealousy, Henry).

Modern Condensing Systems

SYNOPSIS—Relative advantages of surface and jet condensers and a comparison of reciprocating and rotary pumps, special attention being given to Westinghouse-Leblanc designs.

❖

In a paper read before The Institution of Mechanical Engineers, A. E. Leigh Scanes presented an interesting discussion on the development in condensing systems which has taken place during recent years. He considered briefly surface and jet condensers and gave considerable space to air pumps, dealing, particularly, with the Westinghouse-Leblanc dry-air pumps. Circulating

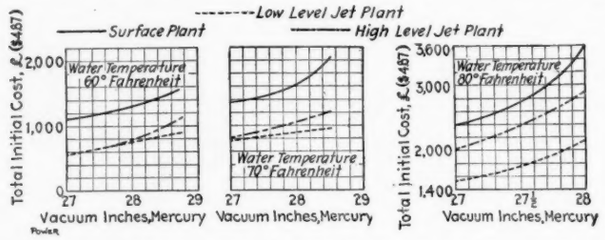


FIG. 1. COMPARATIVE INITIAL COSTS OF VARIOUS TYPES OF CONDENSER

pumps, extraction pumps and vacuum traps were also briefly treated.

In the paper surface condensers were divided into two classes, those in which the cooling water passes through the tubes and those in which the steam is condensed in the tubes by a small quantity of water flowing over their exterior. The jet condensers were divided into high level or barometric, low level, and ejector types. As a guide in choosing a plant, the series of curves shown in Figs. 1 and 2 were presented. Fig. 1 compares the initial cost of the various types and Fig. 2 the operating cost. In each diagram 40,000 lb. of steam per hour and a barometer of 30 in. were used as a basis. In Fig. 1 allowance was made for the original cost of the condensers, cooling

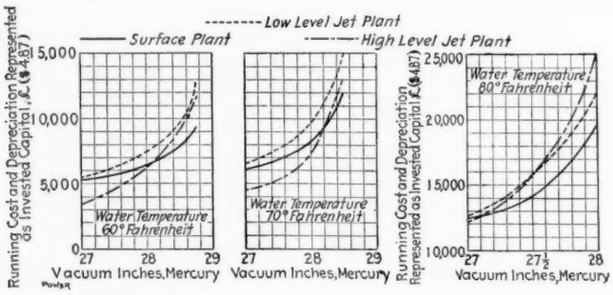

Low Level Jet Plant
Surface Plant
High Level Jet Plant
Running Cost and Depreciation Represented as Invested Capital, £ ($487)
Water Temperature 60° Fahrenheit
Water Temperature 70° Fahrenheit
Water Temperature 80° Fahrenheit
Vacuum Inches, Mercury
POWER

FIG. 2. COMPARISON OF RUNNING COSTS AT ½d. (1c.) PER UNIT AND DEPRECIATION CAPITALIZED AT 5 PER CENT.

towers when necessary, and foundations. In Fig. 2, depreciation at 12 per cent. per annum and a running cost of ½ pence (one cent in American money) per unit have been capitalized at 5 per cent.

SURFACE CONDENSERS

In the earlier types of surface condenser, it was stated that a low rate of heat transmission was usual, about 350 B.t.u. per sq.ft. of surface per degree Fahrenheit mean temperature difference, this rate giving a condensation of 5 or 6 lb. per sq.ft. per hr. for moderate vacua and water temperatures.

From the viewpoint of reliability, large surfaces have been preferred, since they are supposed to require less attention and cleaning to maintain a high vacuum. This may be true with moderately clean water, but marine practice has shown that small surfaces are best for reducing the formation of scale, owing to the increased water velocity. Furthermore, this increase of velocity through the tubes also increases the rate of heat transmission from the metal to the cooling fluids. In this connection, Fig. 3 shows experimental results obtained by various authorities.

The author refers briefly to the drop of vacuum caused

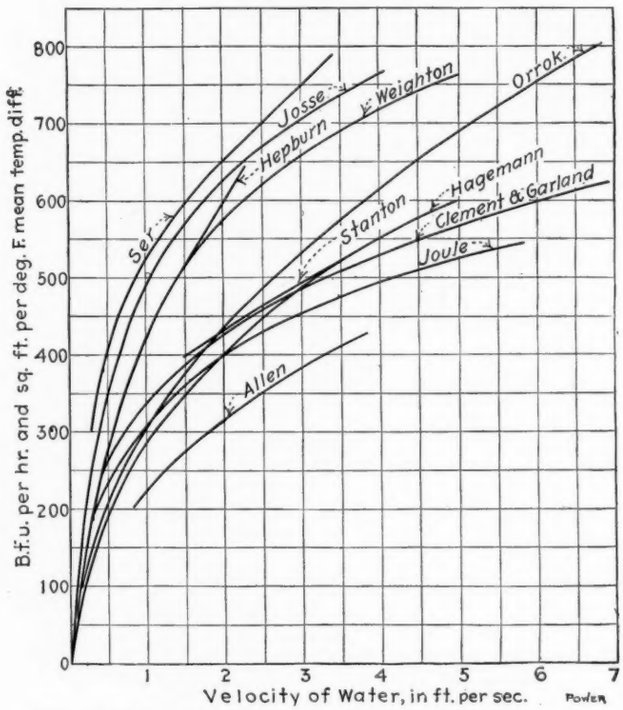


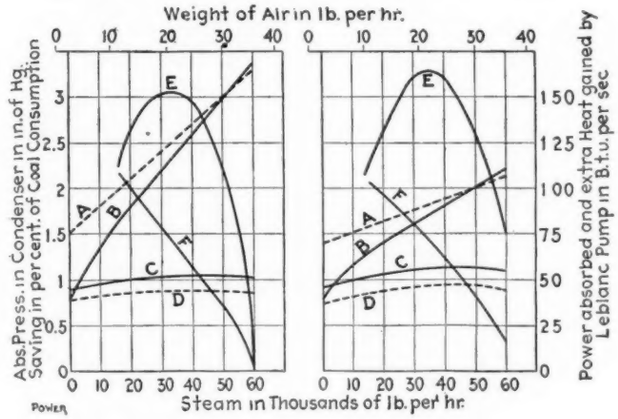
FIG. 3. HEAT TRANSMISSION FROM STEAM TO WATER IN SURFACE CONDENSERS

by the tubes throttling the flow of steam, and the efforts made to overcome this by keeping a constant steam velocity. This was accomplished by placing the tubes farther apart near the steam inlet, making the condenser shell heart shaped to offer a large surface at the top, gradually decreasing to the air outlet, and running passages among the tubes. The first and last methods have been adopted by the British Westinghouse Electric & Manufacturing Co., and some illustrations of their condenser were presented with test data to show the efficiency of operation. Air logging of the bottom tubes and vacuum efficiency were also given brief mention.

JET CONDENSERS

This type of condenser may be used when the supply of cold water available either from natural sources or from a cooling system is suitable for boiler-feed purposes. Even when this is not the case, but the water is of a qual-

ity which would rapidly scale or pit the tubes of a surface plant, jet plants can often be used in conjunction with a purifier for feed purposes. The power absorbed by the pump is usually higher than for a surface plant, although the actual water quantity required is considerably less, the excess power being due to the water being extracted from the condenser body against the vacuum head (which is approximately 32 ft.) in addition to any external pressure. The air pump must also be larger to deal with the air liberated from the water, usually not less than 2 per cent. of the volume at atmospheric pressure. Reference was made to the earlier forms of jet condensers, and a description was given of the Westinghouse-Leblanc multiple-jet condenser.


Weight of Air in lb. per hr.
Abs. Press. in Condenser in in. of Hg.
Saving in per cent. of Coal Consumption
Power absorbed and extra Heat gained by Leblanc Pump in B.t.u. per sec
Steam in Thousands of lb. per hr.
POWER

FIGS. 4 AND 5. RELATIVE OPERATING DATA OF LEBLANC AND RECIPROCATING PUMPS

A Absolute pressure in condenser with wet piston pump.
B Absolute pressure in condenser with Leblanc pump.
C Power absorbed by Leblanc pump.
D Power absorbed by wet piston pump.
E Net gain in B.t.u. obtained with Leblanc pump.
F Percentage of coal consumption saved with Leblanc pump.

Barometric jet condensers are similar to the low-level type with the exception that the hot water and condensed steam are removed by means of a barometric leg instead of an extraction pump. The disadvantages consist of greater expense, more room occupied and loss of vacuum between the condenser and main unit, due to the abnormal length of the exhaust pipe. This loss may vary between ¼ and 1 in. of mercury. In the majority of cases, a low-level jet is to be preferred, the only condition where a barometric plant is advisable is when the cooling water is at a level which does not necessitate an injection pump.

For very small steam quantities, ejector condensers are employed. A diagram of one of the best forms of the older designs was shown in the paper and also a diagram locating the critical point. The Westinghouse-Leblanc simple jet condenser was illustrated.

AIR PUMPS

Considerable space was given to air pumps, and, as with the other apparatus, most of it was devoted to the Westinghouse product. Brief mention was made of the Parsons vacuum augmenter, reciprocating pumps, the rotary spray air pump, and a simple water-ejector type of air pump, but most of the space under this division of the paper was devoted to the Westinghouse-Leblanc dry-air pump. Its advantages were pointed out and comparisons made with other types of pump. Diagrams showing the comparative floor space occupied by Leblanc pumps and reciprocating pumps were given, and also an illustration, showing the new method of operating the pump in connection with a tank in which the water level is above the suction. The advantage of this arrangement over the old method of drawing the water from a seal-well below the axis of the pump is apparent. Should the vacuum fail for any reason, the pump remains primed, and on the leakage being topped it picks up again without attention.

Figs. 4 and 5 show graphically the relative power absorbed by a Leblanc rotary air pump, including rotary hotwell pump, delivering to 10 ft. external head, compared with a reciprocating wet-air pump of good design. In Fig. 4 full load has been taken at 27 in. vacuum, and in Fig. 5 at 28 in. vacuum. The power has been given in B.t.u. for the sake of simplicity, an overall efficiency of 20 per cent. being assumed. The other curves give the respective total absolute pressures in the condenser, the total heat returned by the rotary pump in the hotwell in excess of that returned by the piston pump, the net gain in B.t.u. and the overall gain in coal consumption, assuming that live steam at 100 per cent. efficiency be used to raise the hotwell temperature before entering the economizer, in the case of the piston pump.

In calculating the net gain and B.t.u., allowance has been made below full load on the condenser for the decreased steam consumption for equal power outputs, due to the higher vacuum maintained by the Leblanc pump.

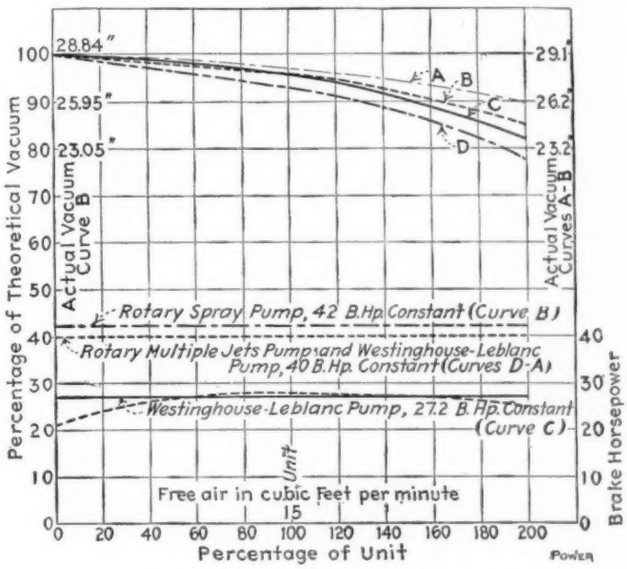


FIG. 6. TEST RESULTS FROM ROTARY PUMPS

Barometer during test of rotary spray pump 29.47 in. hg. Temperature of water used 64 deg. F., corresponding to a water vapor tension of 0.63 in hg. Theoretical vacuum 28.84 in.

Barometer during test of Westinghouse-Leblanc pump 29.78 in.

Temperature of water used 68 deg. F., corresponding to a water vapor tension of 0.68 in hg. Theoretical vacuum 29.1 in.

Curve A—Vacuum obtained with Westinghouse-Leblanc pump absorbing 40 b.hp.

Curve B—Vacuum obtained with rotary spray pump absorbing 42 b.hp.

Curve C—Vacuum obtained with Westinghouse-Leblanc pump absorbing 27.2 b.hp.

Curve D—Vacuum obtained with rotary multiple-jet pump absorbing 40 b.hp.

This decrease has been taken as 5 per cent. mean between 27 and 28 in. vacuum, and 6 per cent. between 28 and 29 in. vacuum. In Fig. 6 curve *C* shows a test on a Leblanc pump superimposed on the test of a rotary spray pump. The pumps are of approximately the same capacity, and it

will be seen that the power taken by the former is considerably less than by a rotary pump.

Circulating Pumps

In the section devoted to circulating pumps, reference was made to the tendency of purchasers to look only at the initial outlay and overlook running efficiency and reliability. In choosing a centrifugal pump it must be remembered that the speed at which the pump is to work is fixed for a maximum efficiency. The first point to settle then is the most suitable speed for all conditions of service. The next point is to consider if it is advisable to run this pump from the same motor or engine which is to drive the air pump. With reciprocating air pumps this is usually done with the help of gearing, but this arrangement is not usually liked on account of the noise, and the best alternative is a rotary air pump which, when possible, should be run at the same speed as the circulating pump.

When the cooling water has to be lifted against a low head, however, the circulating pump must be run at a relatively slow speed, which would naturally detract from the efficiency of the air pump, and in this case separate motors would be advisable. When a cooling tower must be used, and the head against the circulating pump is 30 ft. or more a high speed can be utilized and all the pumps direct coupled. Even with the high head the efficiency of the water pump will be relatively low—about 65 per cent. for a speed of 2500 r.p.m., but the advantages of a self-contained unit, which does not depend on the main plant for power, usually more than compensates for this and the additional initial outlay involved.

Extraction pumps for use with surface condensers were given a paragraph, and similar space was given to vacuum traps for removing condensation from exhaust lines when there is a fall in the exhaust pipe toward the engine.

The extended discussion following the paper was largely devoted to the operation of the Leblanc pump, its early faults and its development. Capt. H. D. Sankey thought that the Leblanc pump was specially suitable when a good vacuum was required, as in the case of turbines. With reciprocating engines where a vacuum of 26 to 27 in. sufficed, the reciprocating pump probably had the advantage.

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Progress of the 1915 Exposition

While the construction of the Panama-Pacific International Exposition, to be held in San Francisco in 1915, is breaking all records in its progress, arrangements are being made for innumerable conventions and conferences to meet at the Exposition in 1915.

Every trade and profession in the world will be represented in some form in the exhibit section and it is intended that similarly, every trade and profession shall be represented in convocation. In planning the Exposition, such ample provision has been made for the accommodation of conferences, that already hundreds of applications have been received from all parts of the world for dates to hold gatherings and festivals. The most notable of the conferences already arranged for are the International Peace Conference, Conventions of the Inter-Parliamentary Union, the Institute of International Law and the Pan-American Congress. Other conferences in the interest of commerce, public health, art and music are being arranged.

All building will be fully completed eight months before the opening of the Exposition. By August, 1914, many of the exhibits will have been installed and the grounds terraced and planted with trees and flowers. Every detail of the Exposition will be perfected at least two months before the opening date.

The Flood

No disaster since the Galveston flood and the San Francisco earthquake can be compared to that which the daily press has depicted the past two weeks of the flood in the Middle West. Of the extent of the loss of human life and the suffering and destitution of the survivors no accurate estimate can be made at this writing (Mar. 31). One day it is stated that the dead will number between 500 and 1000, and the next it is said that "fire or the flood has claimed thousands of the missing." This account is taken from the news reports as they were published and its statements must be regarded with more or less reservation.

Of the states most afflicted, Ohio, Indiana, Pennsylvania and West Virginia, Ohio has suffered the most in this calamity. Dayton, Cleveland, Columbus, Zanesville, Steubenville, Tiffin and Delaware, where the greatest damage occurred, are under martial law, and food, clothing and medical attendance are being dispensed systematically and effectively.

The cities' water-works and sewerage systems are being rapidly restored to operating conditions where possible, to prevent fever. Some of the systems only need repairing of the equipment.

Many of the factories in these cities have been either entirely demolished or the machinery and power plants wrecked beyond repair. In several cities some time must elapse before the lighting and power plants and the gas service can be restored.

In Indiana, Peru, West Indianapolis, Fort Wayne, Lafayette, Logansport, Terre Haute, Kokomo, Martinsville, Shelbyville, Connorsville and many other smaller towns were devastated.

Most of the Dayton office buildings are intact, and need only to be cleared of mud and débris and the power plants freed of water.

The plant of the Dayton Light, Gas & Coke Co. was destroyed by fire. The electric light and gas plants are said to be uninjured. Later Dayton dispatches say that: "The first call to work was issued today (Mar. 29) and by Monday morning the reassuring notes of factory whistles will relieve distraught minds of men and women who are still nerve-racked and ill from an experience that has been little less terrifying than Galveston's."

This call comes from the Dayton Engineering Laboratories Co., the youngest of the city's big industrials. Its million-dollar plant, manufacturing electrical starting apparatus for automobiles and employing 1100 men, was in the center of the worst flooded district, East First and Foundry Sts. Seventeen feet of water submerged the concrete building to within 18 in. of its second floor.

Many of the large manufacturing plants and shops have been forced to close down owing to the lack of transportation facilities, thus making an additional hardship on hundreds of employees.

The power plant of the Dougherty Co. and the dam in the Black River, which supplied power for lighting Elyria, Ohio, were destroyed by high water late Tuesday afternoon, Mar. 25. The water from the dam swept away the power house and a 70-ft. span stone arch bridge connecting the two halves of the city. The loss is estimated at over $70,000.

At Cleveland the unprecedentedly high water in the Cuyahoga River flooded the basement of the Canal Road plant of the Cleveland Electric Illuminating Co., and partially shut it down. Street lamps in the business section went dark and a number of the larger stores and business places were only partially supplied with light at night.

At Mansfield, Bucyrus and Ashland, Ohio, the municipal lighting plants have been shut down by high water.

The property loss in Ohio alone will probably reach $300,000,000.

As this paper goes to press it is reported that the Mississippi River is rising, and there are fears of great property loss, the flood having already spread over large areas in Missouri. The loss of life will undoubtedly be very small, if any, as the inhabitants have been warned in time to flee to the hills.

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Annual Dinner of New York City N. A. S. E.

On Thursday evening, Mar. 27, the annual dinner of the ten combined associations of Manhattan and the Bronx, National Association of Stationary Engineers, took place at the Broadway Central Hotel. The dinner was highly enjoyed by the 350 members and guests, and much deserved credit is due the banquet committee, Samuel I. Schaff, Fred G. Jolley,

Harry J. Marks, William M. Logan and Frederick Felderman.

Robert Johnson, as toastmaster, introduced as the speakers, Past President Edward H. Kearney, Vice-President James R. Coe, the Hon. William S. Bennett and J. D. Taylor, and Chairman Joseph F. Carney, of the National Board of Trustees, made the address of welcome.

The entertainment features included a broadside from that strong battery of wit, talent and humor, Herbert Self, baritone; Jack Armour, humorist; M. J. O'Connell, tenor; Joe McKenna, comedian, and Billy Murray, of phonograph fame.

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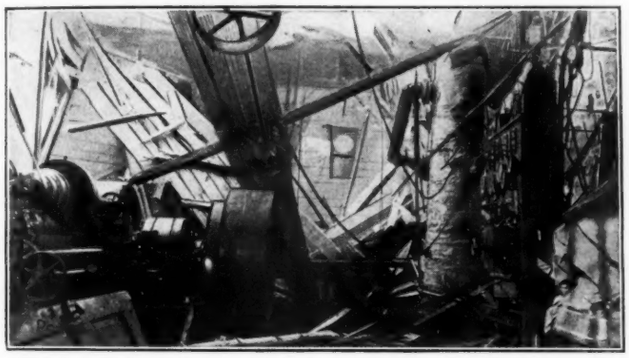
Town Water Tank Burst

On the night of Mar. 10 the water-supply tank of the city water works at Ohio, Ill., burst and wrecked the electric light plant and pumping station, which were located almost beneath the tower.

The 50,000-gal. capacity tank was made of 3-in. staves and had been in use about 18 yr. Some of the hoops were badly rusted, which was the cause of the disaster. Although one side of the tank fell on the boiler room, taking the smokestack and steam pipes with it, and filling the boiler room with cold water, practically no damage was done to the boilers, which were under pressure at the time.



WRECKED PLANT AND STATION AT OHIO, ILL.

As this plant was the city's only source of water supply, something had to be done quickly; so a traction engine was brought in from the country and used to furnish steam for one of the pumps which was not badly damaged. This worked so well that it was decided to try to run one of the generators in the same way. A larger traction engine was run up as closely as possible to the other side of the building and the steam piped to a 10x12-in. engine, which also had escaped being wrecked. In this way the town is being supplied with lights and water until the plant can be put in shape again and a new tank erected. The service was only interrupted for about 6 hr.

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Boiler Inspector Bill for New Jersey

Assemblyman Quinn's bill to authorize the governor of New Jersey to appoint a state boiler inspector at $3000 a year passed the Assembly on Mar. 27. The House of Representatives some time ago defeated the bill.

If the bill becomes a law the state boiler inspector will be able to appoint three deputies at salaries of $1800 each.

Former Street and Water Commissioner Thomas P. Connelly, of Jersey City, who is a boiler maker, is among those named as candidates for the position of inspector.

The bill, according to the daily press, has the hearty support of the Boilermakers' Union and other labor organizations.

SOCIETY NOTES

The second annual banquet and entertainment of Local 172, International Union of Stationary Engineers, composed of the engineers of the public schools of Greater New York, will be held at the Broadway Central Hotel on Saturday evening, Apr. 26.

PERSONALS

J. M. Curtin, formerly assistant manager of the industrial and power department of the Westinghouse Electric & Manufacturing Co., at East Pittsburgh, has been appointed manager. Mr. Curtin is a graduate of Penn State College, and has been identified with the Westinghouse company ever since his graduation.

Homer Whelpley, secretary of the National Exhibitors Association, will resign on May 1 from the employ of Strong, Carlisle & Hammond to go with the Fisher Governor Co., Marshalltown, Iowa. His headquarters will be at 659 East 107th St., Cleveland, Ohio. With the latter company, Mr. Whelpley will be Eastern sales manager of territory comprising all states east of the Mississippi River, including the Southern states. He has been with Strong, Carlisle & Hammond about eight years as sales-manager of the steam specialty department, has been secretary of the National Exhibitors Association for the past two years and is now its vice-president.

Charles Robbins, since 1909, manager of the industrial and power department of the Westinghouse Electric & Manufacturing Co., has been appointed its assistant sales manager, with headquarters at East Pittsburgh. Mr. Robbins became associated with the company in 1899 and was for a number of years located in New York City. Previous to his connection with this company he was associated with the Cutter Co., of Philadelphia. He is a member of the National Electric Light Association and the American Institute of Electrical Engineers, having been closely identified with the latter organization in connection with the standardization work and prominently identified with the committee on rating

Prof. Ira N. Hollis, of Harvard University, has accepted the presidency of the Worcester Polytechnic Institute, of Worcester, Mass. He was educated in the public schools of Louisville, Ky., and after a year's work in a machine shop was appointed to the U. S. Naval Academy. He graduated at the head of his class in 1878 and entered the Engineering Corps. The succeeding 15 years were spent in various work in the navy, both at sea and on shore. In 1893, while serving under the late Rear-Admiral Melville, he resigned to take the professorship of engineering at Harvard University. During 1892 he delivered a course of lectures at the Naval War College on "The Ships of Our Modern Navy." These lectures were afterward issued to the service in book form. At Harvard he was charged with the duty of developing the engineering instruction, and he remained at the head of the department for 16 years. In 1899, he received the honorary degree of A. M. from Harvard and has since received honorary degrees from other institutions. He is president of the Engineers Club of Boston, vice-president of the American Society of Mechanical Engineers, past-president of the Boston Society of Civil Engineers, and has served on the council of the American Academy of Arts and Sciences. He is a member of the Society of U. S. Naval Engineers, the American Society of Naval Architects and Marine Engineers, the Society for the Promotion of Engineering Education, and the Massachusetts Military Historical Society. He has contributed many articles to engineering and naval journals, and in intervals of leisure he wrote the "History of the Frigate Constitution."

NEW PUBLICATIONS

COMMERCIAL ENGINEERING. By Alfred J. Liversedge. Published by Emmot & Co., Ltd., Manchester and London, Eng. Cloth; 369 pages, 6x8½ in.; tables; indexed. Price, 7s. 6d. ($1.87) net.

The book reproduces a series of articles which appeared in the "Mechanical World" and is intended to fill the gap between college or apprenticeship and active responsible participation in business. It was written by a general manager, thoroughly familiar with his subject and covers a wide field dealing with materials, labor, facilities, productions, markets, tariffs; weights, measures and values in all countries; contracts, organization and legislation. Particular attention is given to the world's markets. The book gives a great deal of information in condensed form that would not be readily available, and besides helping the man breaking in, it should be valuable to the engineering man of business.

Advantages of the Steam Turbine

By John S. Leese

SYNOPSIS—A few of the advantages of the steam turbine over the reciprocating engine.

The differences in economy and general efficiency of turbines and reciprocating steam sets are of interest. In steam turbines are no rapid changes in direction of the moving parts or in stress resulting therefrom, thereby minimizing likelihood of failure from mechanical and structural defects.

The steady rotation of the turbine shaft reduces shafting and transmission troubles and is more adaptable for driving electric generators and textile mills than the comparatively uneven torque obtained with belt-driven reciprocating sets.

The cost of operating steam turbines, properly installed, designed and operated, is considerably less than that of reciprocating units, above a certain horsepower. This may be disputed from evidence to the contrary where reciprocating engines have shown more favorable results, but where the two types can be compared on the same basis, the turbine will make the better showing. The first cost is also less than that of a reciprocating engine for any sizes above 1000 kw. capacity.

The frictional load is less and, therefore, the mechanical efficiency higher. The frictional losses may be as much as 20 per cent. of the indicated horsepower of a reciprocating engine. Moreover, the turbine has almost no loss by condensation, as the stator casing and the rotor are kept at practically the temperature of the steam at its corresponding pressure throughout the range of expansion, owing to its continuous passage, and radiation is the only means of heat loss which would produce internal cooling.

The benefits from using superheated steam are not the same in the turbine and reciprocating engine, although they are considerable in both. The increased economy of the reciprocating engine using superheated steam is because of reduced initial condensation and valve leakage. The turbine benefits by the reduced frictional resistance offered to the rotor by the drier steam, in addition to the reduction of steam leakage past the blades.

Using superheated steam with a reciprocating engine is not always advisable, but turbines have no parts to be damaged by lubrication failures or by increased surface friction from undue expansion. Any unequal expansion occurring in a turbine running at high speeds, however, may throw the rotor out of balance or strip blading.

As a turbine requires no internal lubrication the condensed exhaust steam can be used as feed water.

The efficient operation of a condensing plant is encouraged more by turbines than by reciprocating engines, since the economies obtainable from "that last inch of vacuum" are considerably increased in turbine plants. Little is to be gained by striving for a better vacuum than 26 in. in a reciprocating plant, but the difference between the efficiencies at 26 and 28 in., and higher, with a turbine are worth attaining.

The disadvantages of the turbine compared with its reciprocating rival are few. Although the steam consumption per horsepower-hour is less than in a reciprocating engine so long as high speeds are maintained, it is considerably greater at low speeds. Reliable means of indicating a steam turbine are not available, but the developed horsepower may be approximately figured from the switchboard readings.

The introduction of the low-pressure and mixed-pressure turbines has attracted attention on account of the efficiencies and economies they have shown when applied to the exhaust of reciprocating engines. The mixed-pressure turbine is an exhaust-steam turbine with a high-pressure stage, to which live steam may be admitted, either to maintain the speed when the supply of low-pressure steam is insufficient or when it is absent altogether.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared for the construction of a water-works system at Groveland, Mass. Estimated cost, $40,000.

The Andrew Terry Co. is preparing plans for the construction of a power plant in connection with its establishment at Terryville, Conn.

Plans are being considered by the International Brewing Co. for the construction of a boiler house in connection with its plant at Niagara and Albany Sts., Buffalo, N. Y.

The Consolidated Gas & Electric Co., Baltimore, Md., will construct an addition to its boiler house at Westport, Md.

SOUTHERN STATES

Plans are being considered by the Raeford Co. for the construction of an electric-light plant at Rockfish, N. C.

The Tidewater Power Co. is preparing to construct a substation at Winter Park, Wilmington, N. C. A. B. Skelding, Wilmington, is general manager.

Preliminary arrangements are being made by the Woodland Electric Light & Power Co. for the construction of an electric-power plant at Woodland, N. C. E. G. Griffin and C. J. Parker are interested.

An election will be held at Guyton, Ga., on Apr. 15, to vote on the proposition to issue $15,000 in bonds for the installation of an electric-light plant and water-works system.

The Columbus Power Co. contemplates the construction of a substation and distributing system at La Grange, Ga. Estimated cost, $35,000. J. S. Bleeker, Columbus, is manager.

The Ware County Light & Power Co. contemplates an expenditure of $50,000, for the installation of new equipment in its power plant at Waycross, Ga. J. Wright Reeve, Waycross, is manager and superintendent.

Bonds to the amount of $7000 have been voted for the construction of a water-works system at Fort Myers, Fla.

The citizens of Hurtsboro, Ala., at a recent election voted bonds for $14,000 for municipal improvements, including the installation of an electric-light plant.

The proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant and water system at Henderson, Tenn., is under consideration.

Elmer Northcutt, of Chicago, Ill., has applied to the city council of Irvine, Ky., to construct and operate an electric-light plant and water system at that place.

The municipal electric-light plant at Midway, Ky., has been purchased by the Kentucky Utilities Co., of Lexington, Ky. Extensive improvements and extensions are planned by the new owners.

CENTRAL STATES

The Petersburg Electric Light & Power Co. has been granted a franchise to construct and operate an electric-light plant at Loogootee, Ind. George E. King, Petersburg, Ind., is manager.

Bids will soon be received by Gardner S. Williams, consulting engineer, Ann Arbor, Mich., for the construction of a power plant and dam for the Eastern Michigan Edison Co., at Belleville, Mich. Estimated cost, $450,000.

Plans are being prepared by B. K. Goodman, chief engineer of Reading, Mich., for the installation of new power-plant equipment, including boilers, engine and generator for the local electric-light plant.

The Western United Gas & Electric Co. is preparing plans for the installation of additional equipment in its power plant at Aurora, Ill.